

The Blast Furnace

Engineering Editor

EDITORIAL

W. Trinks
Barton R. Shover

Dr. J. S. Unger
E. H. McClelland

Vol. IX.

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The Blast Furnace ^{and} Steel Plant

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PITTSBURGH, PA., JANUARY, 1921.

No. 1



AT no other period of the world's history have there been so many technical advances and improvements made as during the four years of the World War, and of no industry has this been more true than of the iron and steel industry, the foundation stone of all industries, which furnished the sinews of war.

Because of the necessity of achieving immediate productive results there has not been that exchange of information as to what was actually accomplished that could be wished for.

It is therefore with pleasure we are able to present in connection with our Annual Review of technical and engineering advancements in the steel industry of this country, comprehensive reviews of activities and results in the foremost steel producing countries of the Old World.

When existing conditions are full of difficulties, the men in charge of operations in the world's foremost industry can always be counted upon to rise to their full height and overcome obstacles.

Steel Industry Experiences Turbulent Year

Review of the Steel Industry During 1920 Shows a Period of Readjustment—Two Distinct Markets Carried Throughout the Year—Export Business Is Larger Than Ever Before.

By B. E. V. LUTY.

IT was a year of commotion and turmoil in the iron and steel industry, not a year of sound activity and orderly progress. A very considerable tonnage was made, and profits were rather large, but there was little efficiency. Neither producers nor consumers will be sorry the year is over and done with.

Two Steel Markets.

At the end of 1919 there were really two steel markets, but the fact was not recognized. The Steel Corporation's prices were those of the industrial board adjustment of March 21, 1919. The independents, for the most part, were securing prices above that level, but the transactions were only for early deliveries, the Steel Corporation having an average of about six months of production on its books, and the common view was that the independents were simply obtaining delivery premiums. Probably few of the independents believed that they could run a market of their own, but they probably felt that as the industrial board prices had been proposed for the remainder of 1919 the Steel Corporation would be dis-

The author states that probably the most remarkable and spectacular feature of the steel industry in the year 1920, was the existence of two distinct markets, covering almost the entire twelve months. The independent steel market advanced above the steel corporation level, even though the customers of the latter were ready to pay the higher price. No one had dreamed that such a condition could possibly occur.

posed to advance its prices in 1920, particularly if the independents blazed the way. Price advances by the independents, however, seemed only to make the Steel Corporation management stronger in its view that a stabilizing influence was needed. The expectation, or at least the hope, of the independents that the corporation would advance its prices did not end when late in the year the independent market began to weaken, for then there was a theory that then, the need of discouraging price advances by the independents having disappeared, the corporation would advance its prices so as to meet the independent market part way. The argument was that even admitting that the corporation had been justified in holding to the industrial board prices for a time, the increases in cost that had occurred, particularly by way of the wage advance of February 1, 1920, and the large freight rate advances of August 26, 1920, would warrant the making of some advances. On November 19 Chairman Gary made a statement that the Steel Corporation would not advance its prices and this statement, though not the first of that nature, was accepted as final. A week later some of the large independents reduced bars,

shapes and plates from 3 cents to the Steel Corporation prices of 2.35 cents, 2.45 cents and 2.65 cents respectively. A few days afterwards some independents reduced wire products to the corporation level, 3.25 cents for plain wire and \$3.25 for nails, while on December 4 it became known that some of the independents were willing to meet the corporation's prices on sheets, 3.55 cents for blue annealed, 4.35 cents for black and 5.70 cents for galvanized. Tinplate was already at the corporation level. Pipe, which had remained in good demand, but the difference between the Steel Corporation's prices and the basis prices of the independents was only \$7 a ton. Still higher prices had been obtained by independents, but only by way of delivery premiums.

Extent of Divergence.

While reference has been made to the existence of two markets, there were in reality many markets. There were differences according to time of delivery, and differences between independents for the same delivery. Being the lowest seller, the Steel Corporation necessarily had to confine its sales to regular customers, and as many of its customers required more steel than could be furnished it was necessary to allot the tonnage available. To an extent some of the independents pursued a similar course. They advanced prices, but not to the limit the market would have permitted, and they too had to confine their sales to regular customers for a considerable part of the time. Some independents, on the other hand, ignored customers as such and treated the trade simply as buyers, the highest bidder getting the material.

It would be impossible to designate the "top" in any commodity, for a tabulation of all sales made in the year would show one top for thousand ton lots, a higher top for hundred ton lots, and a higher top for less than carloads, while some speculators or middlemen sold at the highest prices of all. For fair sized mill lots the top prices were approximately 4 cents for bars, 3.75 cents for shapes and 4.50 cents for plates, the highest prices centering in the month of March. Sheets rose to a basis of about 10 cents, and that basis, plus finish extras, was paid more for automobile sheets than for common black, the total turnover being relatively small. In nails the minimum of the independent market for several months was \$4.25, with some buyers paying several dollars a keg more for spot shipment. These citations of prices are simply suggestive of what occurred in general. No comprehensive summary is possible in a review like this, nor would such a review prove interesting.

The Tonnage.

Production of steel ingots in 1920 was about 40,000,000 tons, or 17 per cent more than the output in 1919, 8 per cent less than the output in 1917 and 1918, the two largest tonnage years, and 32 per cent more than in 1912 and 1913, the two best years before the war. What the output was in proportion to capacity cannot be stated closely. The industry's capacity is known only by performance. The total output is never equal to the sum

of the individual plant ratings, while on the other hand nearly every time the circumstances are favorable a plant breaks its previous record. A computation based on the output of 1916, with allowance for new construction, would indicate an ingot capacity in 1920 of about 50,000,000 tons, but on the other hand a rate of more than 45,000,000 tons of ingots a year was attained in March, when a common view was that the obstacles existing did not permit the plants to average anything like 90 per cent of their real capacity. A fair working factor for capacity, given reasonably favorable physical conditions, such as existed in 1916, is 52,500,000 tons. On that basis the 1920 production was about 76 per cent of capacity.

A fair guess as to the production of pig iron in 1920 is 36,500,000 tons, this comparing with 31,015,364 tons produced in 1919, about 39,000,000 tons in each of the preceding years, and 30,966,152 tons in 1913, the heaviest tonnage year before the war.

As to the blast furnace capacity, that again is something indeterminate except by the actual experience of the furnaces making the iron. The rapid adoption, as circumstances permitted, of the wide hearth has made estimates of pig iron capacity particularly difficult in recent years. In the early months of 1916 the production of pig iron far exceeded the tonnage that had been estimated, on the basis of past performance, as the real capacity. Without allowance for increases in capacity of individual stacks the capacity in 1920 could be set at about 44,000,000 tons, but it is quite possible the furnaces would make more than 46,000,000 tons if given favorable conditions.

Obstacles to Operation.

While production was far below capacity, for practically the entire year the Steel Corporation, and for nine or ten months the independents endeavored strenuously to produce every ton possible. There was a succession of difficulties. The iron and steel strike inaugurated September 22, 1919, had entirely ended as a strike, in the closing weeks of that year, but the disorganization of working forces and the lowered morale remained to be repaired in 1920. The effects of the bituminous coal strike of November, 1919, had not worn off. The new year opened with labor inefficient and in short supply and with coal and coke supplies altogether inadequate. These difficulties were largely overcome during the first two months, and in March the blast furnaces and steel mills began to operate with a fair degree of efficiency. On April 1 the "outlaw" rail strikes began, and in a few days a fresh crippling of the iron and steel industry began, starting in the Chicago district and rapidly moving eastward. Within a few weeks operations were down about one-third from the March rate. Then a gradual recovery began in production, but shipments of pig iron were somewhat less than production, and shipments of finished steel products much less than the output. By the end of June the mills had an accumulation of 2,500,000 to 3,000,000 tons of steel, chiefly in finished form, all urgently needed by customers. Railroad operations began to improve slightly and just before the government guarantee of railway earnings ended, September 1, a marked improvement in freight movement set in. The accumulations of steel rapidly melted away.

Supplies and Prices.

Steel did not become scarce immediately upon the inauguration of the strike of September 22, 1919, as some provision had been made against the possibility of a strike, but it was definitely scarce at the beginning of 1920. If market prices be taken as a criterion, steel was extremely

scarce for more than half the year. In 1906 steel was very scarce, and prices were about 25 per cent higher than at the beginning of 1905. If price advance be taken as the indication of scarcity some forms of steel were from five to ten times as scarce during part of 1920 as they were in 1906, for the price advances were from five to ten times as great. That is not a fair criterion, however. The war had thrown men's minds wide open, and some buyers were willing to pay price advances they would have considered absurd to pay in the steadier times before the war. The character of the demand, moreover, was peculiar. Normally more than half the steel produced passes into permanent employment in forms that represent investment, the investment being calculated to yield an annual return, with eventual liquidation of the principle. For such purposes fancy priced steel could not, of course, be purchased, but the common everyday hand to mouth requirements in 1920 were particularly large. For a time there was a popular superstition that the automobile industry was consuming a very large proportion of the steel industry, but that view was quite incorrect. At no time was the automobile industry, all told, consuming anything like 10 per cent of the current production of steel. It was in making market prices that the industry was active, being quite reckless in bidding for material, not merely steel, but glass, lumber and various other commodities. Sellers were quick to take the cue.

In the retrospect, it is impossible to account for all the steel that was made and consumed, for at the close of the year stocks in all hands were very light in the aggregate. Very little steel passed to the railroads. There was a little construction work, on large jobs, in bridges, buildings, power plants and factories, but on the whole very little. There must have been large consumption in the manufacture of tools and implements of various sorts, and repairs to buildings and to factories were undoubtedly heavy. The petroleum industry consumed an enormous amount of material, particularly in tubular goods, far beyond any previous record. Iron and steel exports were large, by comparison with the share the United States had in international iron and steel trade before the war, but not particularly large by comparison either with capacity or actual output. Nor is it to be expected that the United States will ever engage any really large part of its productive capacity in the export trade, any percentage at all comparable with the percentages Great Britain, Germany and Belgium showed before the war. What is a large tonnage for those countries is a small tonnage for us. The total international iron and steel trade before the war, excluding movements between producing countries, was equal in tonnage to barely one-quarter our present capacity.

Readjustments.

Of course the conditions that developed in 1920 leave a great deal to be readjusted. It cannot be said that if prices had been held down by the independents the iron and steel market would have been preserved. A readjustment would have been requisite, for the whole country had to readjust itself. If, on the other hand, the Steel Corporation had followed the independents in advancing prices the end would have come sooner, and the country as a whole would have been encouraged to carry the process of inflation even farther than was the case.

If everyone, manufacturer, wholesaler, retailer and wage earner, had pursued a moderate course in 1919 and 1920, being willing to work hard for moderate returns, no readjustment would have been necessary. The country

is readjusting itself not from wartime conditions but from conditions that developed after the war.

The recovery requisite is from a psychological not a physical condition. The "bug" in men's minds that by reason of the war everybody can get more for less effort has to be eliminated. That is something that can't be done.

In 1873 there began a five-year readjustment because men had overbuilt and had been doing entirely too much business on paper. In 1893 there began a similar period, because there had been more construction than the country could support. In 1907, again, it was found that there had been too much construction. The most common cause of industrial depressions in the United States has been the conversion of too much liquid capital into fixed capital, the creation of investments that could not yield proper returns until the country had grown up to the new measure.

According to all analyses of the situation this condition does not exist at present. The country does not need to grow up to its capacity, for in many respects its require-

ments are greater than its facilities, particularly in buildings of almost all sorts. What is requisite is a readjustment in the cost, measured in dollars, of doing things, and a readjustment in the minds of men as to what service they must render for the reward business can afford to give them. These changes, in men's mental attitudes and in the prices of commodities and services, require no particular time for their completion. The revival can come soon, or it may be deferred.

As to steel in particular, what is awaited is chiefly a reduction in the cost of consumption rather than a reduction in the cost of production. The latter is the smaller of the two items. The cost of putting steel into employment, from the time it leaves the steel mill until it becomes really useful in its final place, is altogether too great, made so by high wages and indifferent service, by high profits hitherto expected all along the line, and by extremely high prices of many of the commodities that must be used in conjunction with steel. When reasonable readjustments have been completed all along the line the country will require large quantities of steel.

Electrical Review Steel Industry for 1920

Steam Driven Mills Rapidly Being Replaced by the Progressive Application of Electricity to Steel Mill Drives—A Number of Instances Shown Where Steam Equipment Is Being Replaced.

By G. E. STOLZ,

General Engineer, Westinghouse Electric & Manufacturing Co.

THE use of electricity in steel plants is becoming more general each year, the tendency being to eliminate steam, hydraulic and manually operated machinery in preference to motor driven apparatus. There seems to be little question as to the desirability of electrifying new mills, the main problem of the day being how much longer can the present steam driven mills justify their existence.

This general trend towards motor driven machinery naturally increases the demand for large centralized industrial power plants or the purchase of large blocks of central station power. Some times, it is a combination of the two. The purchase of steam turbines varying in capacity from 10,000 to 20,000 kw for steel mill service is quite common, and the tying of several plants together to utilize common spare capacity is becoming more general.

During the last year, one of our moderate sized steel plants found their turbine capacity loaded up to such an extent that they had no spare units available. They negotiated for another turbine; the cost of the machine itself as well as installation charges were entailed for no other reason than to provide spare capacity. Before making the purchase, negotiations for spare capacity was taken up with the local central station power company. This resulted in finally abandoning the idea of purchasing a turbine and a contract was drawn up with the power company which would permit the operating company to take power from the city lines in case one of their turbines failed. A nominal stand-by monthly charge is paid to the power company to hold sufficient capacity in reserve to take care of an emergency demand, and in case

power is consumed by the operating company, an additional charge is made for the kw hours used. If the operating company would have installed a turbine they would have been subject to a stand-by charge which would cover interest, taxes, insurance and obsolescence on their investment for the full capacity required. On the other hand, the charges for the spare capacity held in reserve by the power company can be spread over several of their customers, and this particular operator in this way is able to obtain insurance against a shut down at a fractional cost of that involved in installing his own turbine. To our best knowledge, this spare capacity has not been required as yet, while the customer has had the advantage of operating his entire plant at practically full capacity at its best economy, and at the same time has a ready means of replacing the power generated by one of his turbines in case of failure.

This scheme eliminates the accumulation of machines in neighboring plants, each being idle and held as a spare for the particular plant in which it is installed, while the operation of other plants is not properly safe-guarded due to the fact that practically all of their machines are in service at all times. Where it is possible to make an arrangement of this kind, the scheme will work to the advantage of not only the operating company, but the power company.

The contracts placed this year for large motor equipment include increasing percentage of units which are to be installed to replace steam engine driven mills. This is only natural as the demand for tonnage has fallen off, and at this time, it is more important to be able to operate economically to reduce the cost of producing steel.

Recently a field has appeared for small reversing blooming mill units. Heretofore, the electrically driven reversing blooming mill equipments were placed on mills varying from 34" to 44", but there are a number of plants where the tonnage required per month varies from 10,000 to 20,000 tons, and the installation of a large mill is not justifiable. Very often, small 3-high mills have been installed for these small tonnage plants, but in the last year three of these mills are being designed for reversing drive. The Atlantic Steel Company is replacing their reversing blooming mill engine and have purchased an electric reversing mill equipment to drive a 28-inch mill. The Dominion Foundry & Steel Co., of Canada, are installing a mill which can be made to roll universal plates, sheared plates, or billets on a 30-inch mill. These mills will take blooms approximating 16 to 18 inches square and roll to various sized billets. The Follansbee Bros. Company are now installing a 30-inch, 2-high reversing mill at their new Toronto plant, upon which they expect to finish sheet bar. These small equipments enable the operator to utilize a reasonable size ingot so that it can be worked sufficient to produce a good billet and obtain the tonnage required by the plant, without incurring the larger first cost and overhead charges due to the installation of one of the larger sized blooming mills. This type of mill is also more flexible than the small 3-high mill which is very often utilized in small plants, and

The author in his review of this year again recalls the rapidity with which the steel plants are adopting electricity. A new field which shows potential possibilities during the year, has been that for small blooming mill units. This field has developed principally among small tonnage steel producers.

is much better adapted to rolling a variety of product which often is required where the finishing mills cover a large variety of product.

The West Virginia Products Company have designed a 72-inch, 2-high reversing copper plate mill in order to obtain a larger output than would be possible with a 3-high mill. The success of this type of mill has been very well demonstrated by the tandem plate mill at the Brier Hill Steel Company, where a 2-high reversing rougher is used with a 3-high finisher. This mill continues to break records and has now rolled 207 slabs in one hour and 1,659 slabs in 12 hours. They have also produced 315 long tons of finished plate in 12 hours, rolling as light as 14 gauge. So far, the method of handling the steel before it reaches the mill and after it is rolled has been the only limit to its output. It has been found that the mill is capable of producing 40" x 3/16" plate at the rate of 55 tons per hour. The roughing mill at that time was making seven passes per slab and the finishing four passes. The plate is then put through the mill without any reduction. This is done to allow the next slab from the roughing mill to follow immediately behind the finished plate without any delay. This rate of rolling compares very favorably with the output often obtained on small blooming mills.

At the present time, the Bethlehem Steel Company are replacing their 44-inch blooming mill engine at their Steelton plant, and in a few weeks expect to have the electrical reversing equipment in operation. The flywheel set with its control, switchboard, and other auxiliaries, were installed before the engine was shut down, so that it has only been necessary to remove the engine with its foundations and pour the foundations for the motor and install the latter.

Most of the contracts placed this year for electrical equipment to operate continuous running mills have been for ac constant speed motors, and ac adjustable speed motors installed on merchant, sheet and strip mills. The majority of them will be connected to the mills through geared drive, indicating the increasing reliance which is being placed in herringbone gear units and the desire on the part of the purchases to eliminate slow speed motors having comparatively poor performance which cost more than the moderate speed motor with the gear unit. Another feature which in some cases has given the gear drive a preference is the possibility of obtaining the exact mill speed required instead of being forced to adopt the nearest synchronous speed of the motor.

The importance of maintaining good power factor still receives attention, and there is a tendency to install synchronous motors upon applications heretofore reserved for the induction type of machine. Several installations of synchronous motors on plunger pumps have been made, and it has been found that the synchronous machine is able to meet the requirements with a good factor of safety. The writer had occasion to make some tests on some 500 gallon, 2,300-pound pressure pumps driven by 1,000 hp motors. These motors were geared to the pumps through herringbone gear units. The starting torque was found to be 15 per cent of the full load torque of the motor, and the friction torque, which is the pull in torque, averaged 4½ per cent of the full load rated torque of the motor. Both of these values are approximately one-third of the starting and pull in torques, ordinarily given on synchronous machines. These tests were made by-passing the water during the starting period.

NEW ELECTRIC DRIVEN BAR MILL.

The Pennsylvania Forge Company, Bridesburg, Philadelphia, which for about 15 years has been engaged in the manufacture of pressed and hammered forgings, including forged steel pipe flanges, has recently added to its equipment a five-stand, three-high 22-inch motor-driven bar mill for the rolling of alloy steel billets and bars.

The mill has several interesting features, among which is the complete mechanical handling of the material from the time it leaves the ingot or billet yard until it is ready for shipment as bars or piled as billets for the billet yard. All the drives are electrical from the 1,000 hp motor on the mill to the pusher on the reheating furnace. The mill was designed and built in the company's own plant with the exception of the mill drive and housings, which were purchased from the Anniston Steel Company, Anniston, Ala. The design and construction were under the direction of W. S. Hilton, the company's designing engineer.

Review of Iron and Steel Literature, 1920

A Classified List of the Most Important Publications During the Year, With a Few of Earlier Date, Not Previously Reviewed.

By E. H. M'CLELLAND,

Technology Librarian, Carnegie Library of Pittsburgh.

A SOMEWHAT perturbed year in the steel industry, marked by abnormal economic conditions, has been characterized by a substantial output of literature, including some highly meritorious publications. One significant feature is that among the most important publications of the year are several issued by large corporations. The valuable technical information set forth by these manufacturers evidences an altruistic attitude which is highly commendable.

The following list includes the most important publications of 1920, together with a few of earlier date, not previously noted in these columns, and probably not very widely known.

Prices were not available in all cases; but the omission is not a serious one at the present time when book prices are subject to frequent change and list prices must always be verified.

Fuller information regarding most of the books listed can be found in book reviews. The most extensive record of these reviews appear in the *Technical Book Review Index*, published quarterly by the Carnegie Library, of Pittsburgh, each quarterly issue listing from 500 to 600 reviews of recent scientific and technical books.

Technology.

American Iron and Steel Institute—Year Book, 1919, 494 pages, 1920. The Institute, New York.

Contains proceedings of the two general meetings held in May and October, 1919, in New York.

American Society for Steel Treating—Transactions. Vol. 1, No. 1, appeared in October, 1920. Published at 208 N. Wabash avenue, Chicago. Supersedes the publications of the "Steel Treating Research Association," and the "American Steel Treating Society," which merged in 1920.

Angieles d'Auriac, P. L. E.—Lecons de Siderurgie, 714 pages, 1920. Dunod & Pinat, Paris, 55 fr. 50.

Arnold, John Oliver, and Ibbotson, Fred—Steel Works Analysis. Ed. 4, revised, 419 pages, 1919. Isaac Pitman & Sons, London.

Last preceding edition was in 1907. Revision has eliminated obsolete material, while considerable new matter has been added, especially on alloy steels.

Association of Iron and Steel Electrical Engineers—Yearly proceedings, 750 pages, 1919. The Association, Pittsburgh.

A valuable publication covering a special but important field. The volume for 1919, published about the middle of 1920, contains 38 papers with discussions, presenting in complete form material from the monthly proceedings.

Backert, A. O.—The A B C of Iron and Steel. Ed. 3, 375 pages.

A series of monographs by specialists. In this edition material has been added on the rolling mill industry and on malleable castings. A valuable feature is the directory of steel works of the United States and Canada, revised to July 1, 1919.

Camp, J. M. and Francis, C. B.—Making, Shaping and Treating of Steel. Ed. 2, 614 pages, 1920. Carnegie Steel Company, Pittsburgh, \$5.

First edition was printed in 1919, but not for general distribu-

tion. Edition 2 is slightly enlarged. Though primarily a course in the Bureau of Instruction of the Carnegie Steel Company, and written for non-technical employers, it affords the best concise treatment now in print.

Crowell & Murray—Iron Ores of Lake Superior. Ed. 4, revised. 285 pages. Penton Publishing Company, Cleveland. \$5.

History, geology, mineralogy, exploration, mining, classification, beneficiation, shipment, valuation and analyses; and description of mines and ores, with maps.

Delestrade, Jean—Le fer et ses derives; l'acier dans la construction automobile. 258 pages, 1919. Dunod & Pinat, Paris. 21 fr. 75.

Intended for chemists as well as for designers and engineers.

Duponchelle, J.—Manuel pratique de fonderie, cuivre, bronze, aluminum, alliages divers. 258 pages, 1919. Paris.

Electric Furnace Association—Products of the Electric Furnace: Steel. 15 pages, 1919. The Association, Niagara Falls, New York.

Small pamphlet giving statistics of furnace installations and output, and brief statements regarding chemical composition and physical properties of electric steel castings.

Ellis, David—Iron Bacteria. 179 pages, 1919. Methuen & Co., Ltd., London.

Has a chapter on iron bacteria in relation to the formation of geological strata.

England—Geological Survey—Special Reports on the Mineral Resources of Great Britain, 1919-20. H. M. Stationery Office, London.

Vol. 8 (9s net), Vol. 9 (3s 6d net), Vol. 10 (4s net) and Vol. 11 (10s net), deal with iron ores in various parts of Great Britain.

Escard, Jean—Les fours electriques industriels et les fabrications electrothermiques. 652 pages, 1919. Dunod & Pinat, Paris.

Includes extensive consideration of electric furnace in the manufacture of iron, steel and ferrous alloys.

Fay, Albert H.—A Glossary of the Mining and Mineral Industry. 754 pages, 1920. Government Printing Office, Washington, D. C. (United States Bureau of Mines Bulletin 95.)

Valuable publication, defining about 20,000 technical and colloquial terms used in mining, metallurgy and quarrying, and in the oil and gas industries.

Gages, Leon—Cours de Metallurgie. Ed. 2, 1919. Librerie de l'Enseignement Technique, Paris. V. 1, La fonte. V. 2, elaboration des fers et aciers.

Gerolsky, W.—Die Prufung der Eisen und Stahl-sorten, 1919. Johann Hammel, Frankfurt.

Goodale, Stephen L.—Chronology of Iron and Steel. 294 pages, 1920. Pittsburgh Iron & Steel Foundries Co., Pittsburgh. \$5.

A valuable chronology beginning with prehistoric times and including the important events of the year 1919. Contains information on many subjects outside the iron and steel industry. Indexed by names and subjects.

Gray, Burton L.—Foundry Work. 196 pages, 1920. American Technical Society, Chicago.

A practical handbook on standard foundry practice, including hand and machine molding, cast iron, malleable iron, steel and brass castings, foundry management, etc.

Guttman, A.—Die Verwendung der Hochofenschlacke im Baugewerbe. 213 pages, 1919. Verlag Stahleisen G. m. b. H., Duesseldorf.

Herington, C. F.—Powdered Coal as a Fuel. Ed. 2, revised. 338 pages, 1920. D. Van Nostrand Company, New York.

Edition 2 is considerably enlarged. Includes a long chapter on "Effective Utilization of Powdered Coal in Metallurgical Furnaces." Bibliography is not rearranged but references have been added to include the literature since 1916.

Hibbard, Henry D.—Manufacture and Uses of Alloy Steels. 96 pages, 1919. John Wiley & Sons, Inc., New York.

Reprint of United States Bureau of Mines Bulletin 100, 1915. Contains bibliographies.

Hoyt, Samuel L.—Metallography, Part 1, 256 pages, 1920. McGraw-Hill Book Company, New York.

Part 1 of a proposed three-volume work. Deals with principles and gives directions for preparation of sections and manipulation of the microscope. Includes pyrometric methods and explains significance of physical properties of metals and alloys.

Hultgren, Axel—A Metallographic Study on Tungsten Steels. 95 pages, 1920. John Wiley & Sons, Inc., New York. \$3.

Translation of a Swedish paper with reviews of the work of other investigators. For the advanced worker in metallography.

Ibbotson, Fred—Chemical Analysis of Steel Works' Materials. 296 pages, 1920. Longmans, Green & Co., London, 21s net.

Revision of Brearley and Ibbotson's "Analysis of Steel Works Materials," 1902, but concerned only with chemical methods, omitting pyrometry and microscopy.

Iron and Steel Institute—Journal, Vol. 100. 581 pages, 1919; Vol. 101, 810 pages, 1920. The Institute, London.

These two volumes represent the last half of 1919 and the first half of 1920. In addition to the valuable original papers, they contain, respectively, 88 and 96 pages of abstracts of the current literature in all languages, constituting the best available guide to progress in ferrous metallurgy.

Macfarlane, William—A Practical Guide to Iron and Steel Works Analysis, 1920. Longmans, Green & Co., London. 9s net.

Markham, Edward R.—Tool-Making. Ed. 2. 288 pages, 1919. American Technical Society, Chicago.

Brief consideration of materials and their treatment, including hardening and tempering. Sections on punch and die work, and drop forging dies.

Montgomery, A.—Report on the Iron Ore Deposits at Yampi Sound. 32 pages, 1920. Department of Mines of Western Australia, Perth.

Morgan, J. J.—Notes on Foundry Practice. Ed. 2, 138 pages. Charles Griffin & Co., Ltd., London. 4s 6d net.

Mueller, Erich—Das Eisen und seine Verbindungen. 558 pages, 1919. Theodor Steinkopf, Dresden.

A carefully prepared monograph with numerous bibliographic references.

Namias, R.—Il chimico siderurgico; analisi dell'acciaio e dei prodotti siderurgici. 240 pages, 1919. Ulrico Hoepli, Milan, 5.50 lire.

Oberhoffer, Paul—Das schmiedbare Eisen. 354 pages, 1920. Julius Springer, Berlin. 40 marks.

Palmer, R. H.—Foundry Practice; a Textbook for Moulders, Students and Apprentices. Ed. 2, 390 pages, 1919. John Wiley & Sons, Inc., New York. \$3.

Parsons, Sam Jones—Malleable Cast Iron. Ed. 2, 1919. 175 pages. D. Van Nostrand Company, New York. \$3.50.

Rastall, R. H. & Wilcockson, W. H.—Tungsten Ores.

81 pages, 1920. John Murray, Albemarle Street, London. (Imperial Institute Monographs on Mineral Resources.)

Deals with occurrence, character and uses. Deals briefly with manufacture of ferro-tungsten. Contains bibliography of 138 references.

Rawdon, H. S. and Epstein, Samuel—Metallographic Features Revealed by Deep Etching of Steel. 24 pages, 1920. Government Printing Office, Washington, D. C. (United States Bureau of Standards. Technologic paper 156.)

Rodenhauser, W. and Others—Electric Furnaces in the Iron and Steel Industry. Ed. 3, 460 pages, 1920. John Wiley & Sons, Inc., New York. \$4.50.

Differs but slightly from the second edition. Contains 31 additional pages, devoted in part to discussion of recent types of furnace.

Savoia, Umberto—Metallurgia generale e siderurgia. 529 pages, 1919. Ulrico Hoepli, Milan.

Descriptive, moderately technical work on fuels and refractories and the metallurgy of iron and steel. Includes a chapter on heat treatment.

Scott, Howard—Critical Ranges of Some Commercial Nickel Steels. 195-214 pages, 1920. Government Printing Office, Washington, D. C. (United States Bureau of Standards. Scientific paper 376.)

Simon, E.—Die Schneidstahle; ihre Mechanik, Konstruktion und Herstellung. Ed. 2. 119 pages. Julius Springer, Berlin, 6s.

United States—Labor Department—Industrial Training for Foundry Workers. 68 pages, 1919. Government Printing Office, Washington, D. C.

Training Bulletin 24 of the United States Training Service contains a list of books, but references are brief and inadequate.

Weld, C. M. and Others—Manganese; Uses Preparation, Mining Costs, and the Production of Ferro-Alloys. 209 pages, 1920. Government Printing Office, Washington, D. C. (United States Bureau of Mines Bulletin 173.)

Wellman-Seaver-Morgan Company—The Open Hearth; Its Relation to the Steel Industry; Its Operation and Design. 378 pages, 1920. The Company, Cleveland.

A large, well-illustrated volume based largely on the working data of the engineers of this company, which is a pioneer manufacturer of steel works equipment.

Williams, Robert Seaton—Principles of Metallography. 155 pages, 1919. McGraw-Hill Book Company, New York. \$2.

Bibliography, pages 139-142. Brief course in general metallography, with considerable attention to applications. A text-book for beginners.

Woodworth, Joseph Vincent—Hardening, Tempering, Annealing and Forging of Steel. Ed. 5, 321 pages, 1919. Norman W. Henley Publishing Company, New York. \$3.

Statistics and Trade.

American Iron and Steel Institute—Annual Statistical Report for 1919. 96 pages, 1920. The Institute, New York.

Statistics for the United States and Canada. Four statistical bulletins published during the year, dealt with (1) production of pig iron in 1919; (2) production of rails in 1919; (3) production of pig iron in first six months of 1920; (4) production of steel ingots and castings, finished forms of rolled iron and steel and miscellaneous iron and steel products in 1919.

American Iron and Steel Institute—Directory of the Iron and Steel Works of the United States and Canada. Ed. 19, corrected to May 1, 1920. 489 pages, 1920. The Institute, New York.

Arranged alphabetically by names of companies with indexes by regions and products. Supersedes edition of 1916 and is much superior thereto.

Burchard, Ernest F.—Iron Ore, Pig Iron and Steel in 1918. Published April 20, 1920. Government Printing Office, Washington, D. C.

Advance publication comprising pages 527-584 of the United States Geological Survey's "Mineral Resources of the United States, 1918."

Eckel, Edwin C.—Coal, Iron and War. 375 pages, 1920. Henry Holt & Co., New York. \$3.

An economic study, considering the industrial development of the leading nations, and the effects of the system of industrialism on the community.

Electric Furnace Association—Training Men. 43 pages, 1920. The Association, Niagara Falls, New York.

Papers and discussions at meeting of the Association in Boston, April 8, 1920. Comments of 22 speakers on the problem of securing adequately trained men for furnace operation.

Engerand, F.—Le fer sur une frontiere; la politique metallurgique de l'etat allemand. 1919. Paris.

Engineers Iron, Metal and Electrical Trades Directory—Ed. 14. Kelly's Directories, London, 45s.

England—Industrial Fatigue Research Board—A Study of Improved Methods in an Iron Foundry. 8 pages, 1919. (Report No. 3). H. M. Stationery Office, London.

England—Ministry of Munitions—Report of Commission Appointed to Examine the Conditions of the Iron and Steel Works in Lorraine, in the Occupied Areas of Germany, in Belgium, and in France, 1919. Ministry of Munitions, London.

Fraser, Lovat—Iron and Steel in India. Times Press, Bombay.

Advance chapter of a biography of the late Jamshedji N. Tata, a pioneer in the modern iron and steel industry in British India.

Ironmonger Diary, 1921. 564 pages, 1920. Ironmonger, London.

Fifty-third annual issue. Includes trade directory of British manufacturers of metal products, index to trademarks, and useful information, tables, etc., relating to weights of metal products, gages, composition of alloys, etc.

Klein, Hugo—Die sudrussische Eisenindustrie. 1920. Verlag Stahleisen G. m. b. H., Duesseldorf. 7.20 marks.

Metal Statistics. Ed. 13. 528 pages, 1920. American Metal Market Company, New York. \$1.

Based on figures appearing in the "American Metal Market and Daily Iron and Steel Report," and monthly in the "Steel and Metal Digest." A valuable annual, commendable for the concise form in which information is presented, and for its prompt appearance which is in marked contrast to some of the other annual reviews.

Mineral Industry During 1919—902 pages, 1920. McGraw-Hill Book Company, Inc., New York. \$10.

On pages 337-392, Edwin F. Cone reviews the iron and steel industry for 1919, giving valuable trade and statistical information and a concise summary of advances in technology.

Ryland's Coal, Iron, Steel, Tinplate, Metal, Engineering and Allied Trades Directory—Ed. 15, 1920. Ryland & Co., Ltd., London. £2 12s.

Now includes Ryland's List of Merchant Exporters, formerly published separately.

Stobbs, Thomas—Wire and Sheet Gauge Tables. 107 pages. E. & F. N. Spon, London. 5s net.

United States—Geological Survey—Mineral Resources of the United States in 1919. (Preliminary survey.) 128 pages, 1920. Government Printing Office, Washington, D. C.

A statistical summary published September 8, 1920. Includes iron and steel.

Bibliography.

Many bibliographies have accompanied books and

papers published during the year and the importance of some of these should not be overlooked. Space will not permit any extensive list here, but attention may be called to those in the works by "Herington," "Rastall" and "Williams," listed above. The work by "Hibbard," as originally published in 1915, contained extensive lists of references to the literature prior to that date.

The Journal of the Iron and Steel Institute—Vol. 101, 1920, contains on pages 144-148, a list in chronological order of the principal books and articles in English on blast furnace practice. The same volume contains brief bibliographies of chromium steels (pages 436 and 482) and electrical resistivity of iron (pages 643-644).

Trade Literature.

Trade catalogs published during the year afford much useful information. The Carnegie Steel Company alone issued approximately a dozen publications of interest to steel men. These include edition 7 of the "Shape Book," 354 pages, and edition 21 of the "Carnegie Pocket Companion," 440 pages.

JOURNAL DISPLACEMENTS IN LUBRICATED BEARINGS.

In his experiments on lubrication, Beauchamp Tower took some measurements of the eccentric positions assumed by a journal when running in a lubricated bearing at various speeds. Some more precise measurements made by a new optical method, of these displacements were conducted last year at the Reichsanstalt by V. Vieweg and A. Wetthauer, and subsequently described in the "Archiv fur Elektrotechnik". The experiments were made to test the theory of journal lubrication which Gumbel explained before the Schiffburtechnische Gesellschaft (in the Jahrbuch, 1917, page 236), and which he subsequently confirmed by measurements of his own. According to Gumbel there would, in the first instance, be dry or semi-dry friction even in a lubricated bearing owing to the roughness of the two surfaces in contact. When the journal is turned, it is first lifted slightly and displaced, with clockwise rotation, to the right. When the journal is lifted higher, and the interlocking projections became entirely disengaged, the friction will be liquid, and the journal is displaced to the left. The method by which Vieweg and Wetthauer measured the displacements is the following. On the front of the journal they fixed a metal plate bearing a cross-ruling of dark lines, like a graticule; they watched this plate through a microscope to determine the center about which the journal was actually rotating at any moment. If the center coincided with an intersection of two of the crossed lines, that point would appear dark and surrounded by more or less distinct dark circles provided the speed was sufficiently high as no longer to show the network of lines. If the center coincided with a light spot between the crossed lines, the observer would see a light central spot surrounded by a small dark circle and further by very faint rings.

The main measurements were made on an electric motor of 50 hp, resting with its journal, 250 mm long, 65 mm diameter, in a full bearing, and run at speeds up to 850 rpm by belting. It was found that the direction of the belt pull, from right or left, made no difference in the measurements. During the first period of dry or semi-dry friction the shaft vacillated, and exact measurements were hardly possible.

By-Product Coke Oven Department

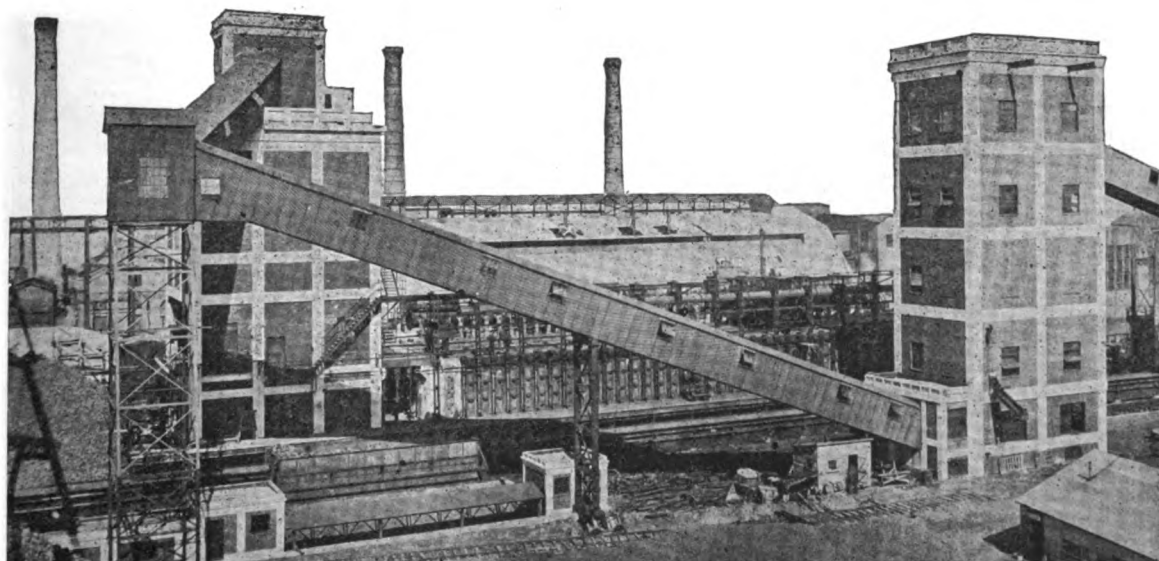
By-Product Coke Oven Plants of Yesterday and Today

By J. M. HASTINGS, Jr.

Jones and Laughlin New By-Product Plant

The By-Product Coke Oven Industry 1920

By C. J. RAMSBURG.



By-Product Coke Oven Plants of Yesterday and Today

Progress of the Art in 28 Years as Illustrated by Old and New Plants of the Semet-Solvay Company—Despite Improvements the Original Characteristics Still Remain.

By J. M. HASTINGS, JR.

AMONG the various points of interest in a modern steel plant, a casual visitor on a tour of inspection is shown the coke oven plant, though a bit cautiously, since dust and dirt are sometimes integral parts of that plant. He sees several hundred ovens in long rows, is told how many thousand tons of coal are charged daily, the tonnage of coke produced, the number of millions of feet of gas released, and the quantities of by-products recovered. He notes the tall gas washing columns, the exhausters, the miles of piping, and comes away with tar on his shoes, coal on his hat and a general, hazy impression of red hot coke and tremendous clouds of steam, altogether a very large plant operating with little fuss and surprisingly few men. Such is his present impression, but to appreciate properly the time and labor required to make possible this huge, modern industry, he must look back into industrial history some 30 years.

In those days, prior to 1890, all the metallurgical coke used in this country was made in beehive ovens,

which literally advertised their presence in the coal mining districts with a "cloud by day and a pillar of fire by night". Coal was cheap, coke was cheap, and the economic value of the by-products was recognized only by a few farsighted men. For some time, however, the officials of the Solvay Process Company, of Syracuse, N. Y., had seen the necessity for a coke oven plant which could not only supply coke for their lime kilns but could also provide the ammonia required in the manufacture of alkali. Influenced partly by their own immediate requirements and partly by a true realization of the principles of the conservation of natural resources, after due consideration, the American rights to the by-product oven designed in Belgium, by Louis Semet, and known as the Semet-Solvay Oven, were secured, and early in 1892 construction was started on the first plant at Syracuse. A few years later this new business had grown to such a proportion that the present Semet-Solvay Company was organized.

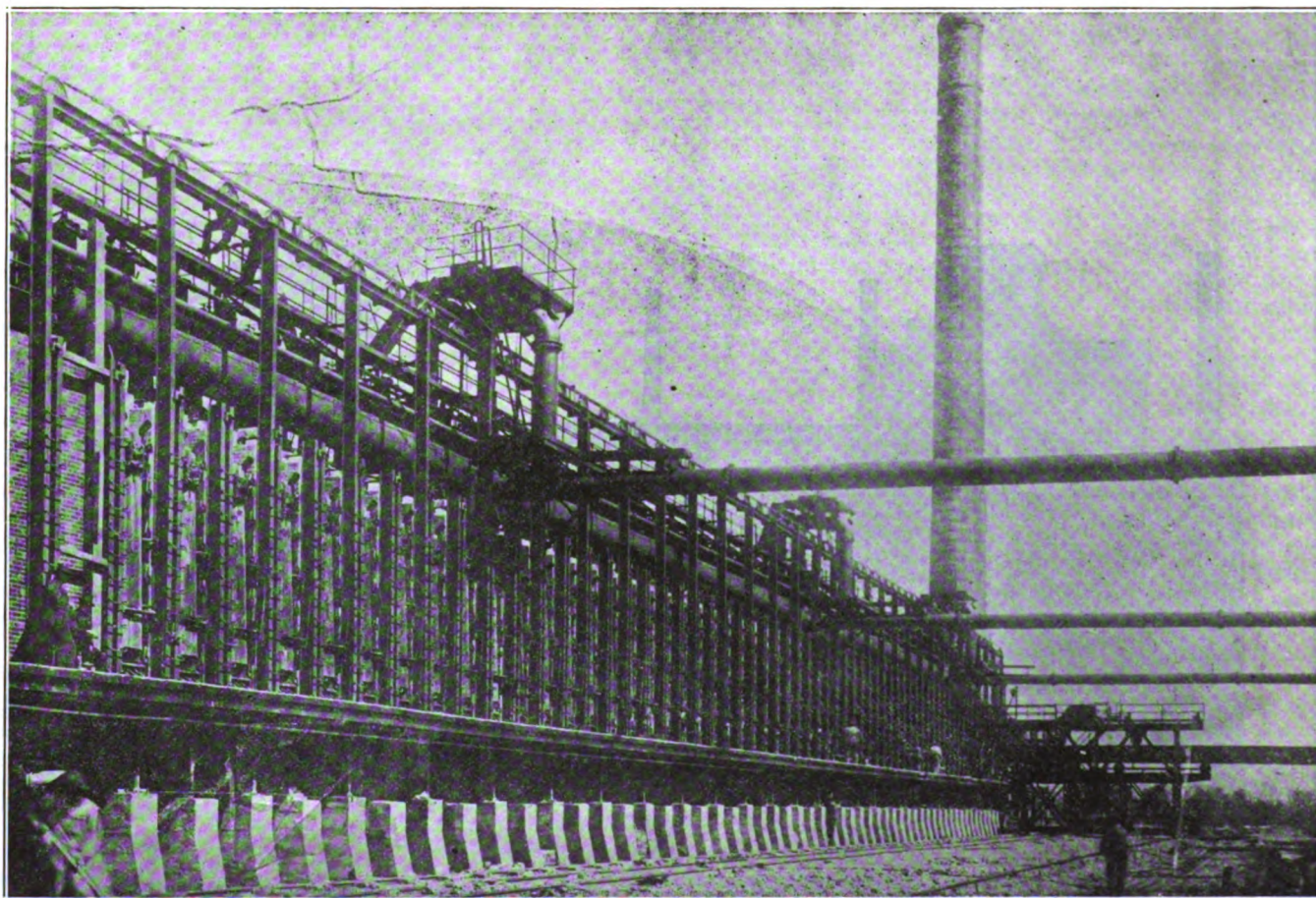


Fig. 1—Modern Semet-Solvay Ovens. Front view, showing modern type dry hydraulic main.

Construction of this pioneer plant was by no means the every-day affair that the building of coke ovens has since become. There were no standards to follow, no details which had been proved by actual use. No foundries had made castings of the particular type required, and no patterns had ever been prepared. Moreover, nowhere in the United States was the refractory material manufactured in the proper form with which to line the ovens and even given that material, no construction engineer experienced along these lines was available to undertake the work. It was necessary to import from Europe all the lining bricks which were heavy shapes shown in the photograph known as "Belgian Tile", and to send to Belgium a man who could study the construction and operation of the ovens and learn the practical details. Despite difficulties of this kind, however, the construction progressed rapidly, and in December, 1892, the 12 ovens were completed and the plant was put in run under the directions of the construction engineer, Thomas Morris, who became the first superintendent. It speaks highly for the ability and perseverance of the engineers in charge of the construc-

were all charged from small hand-pushed larry cars and then cautiously leveled off with a long handled hoe, the leveler standing on a small portable platform. When an oven was pushed, after 36 hours coking period, it was considered sufficient cause for summary discharge, if the unfortunate pusher operator permitted the ram head to so much as touch one of the oven walls. Regularly every morning the superintendent inspected the hydraulic main with the use of a spirit level to make certain that the entire main remained absolutely level since the variation of a fraction of an inch was considered fatal to good operation. It was firmly believed that the linings would give way if the ovens became too hot and that the contraction must certainly prove fatal if they were allowed to cool down. Only after years of careful experiment was the inherent strength of the Semet-Solvay oven design successfully demonstrated to the extent that the questions of obtaining 14 hour coking time or closing an entire plant down cold for six months and then starting up again without trouble became merely matters of operating routine. It should be noted that

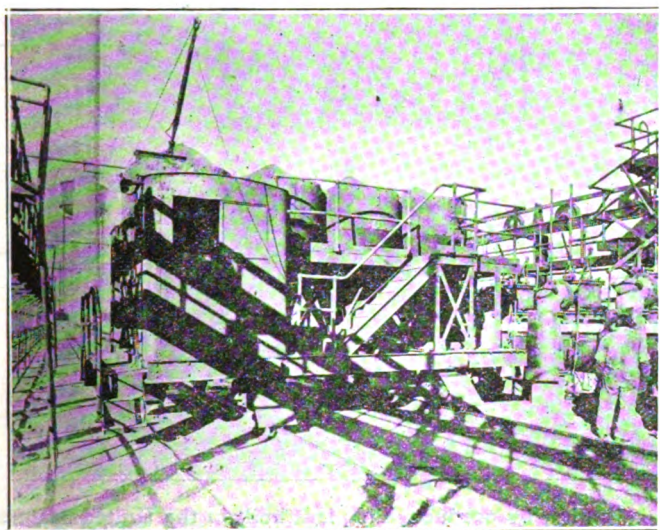


Fig. 2—Modern Semet-Solvay self-cleaning charging car electrically operated.

tion and operation of the first few blocks of ovens that there has been an entire absence of failures in Semet-Solvay plants.

Considering the modern ovens, these first 12 were veritable pygmies. The inside dimensions of each oven were, length 30 feet, height 66 inches, and width varying from $16\frac{1}{2}$ inches on the pusher side to 17 inches on the discharge side. Only by using the greatest care could a charge of $4\frac{1}{2}$ tons of coal be made. Compare this with the modern Semet-Solvay oven, 35 to 40 feet long, 12 feet high, and 17 to 19 inches wide, taking nearly 16 tons at a charge. An interesting illustration of the results of 20 years of development work along strictly American lines, using the same general type of oven, is shown by the contrast between the capacities per oven per day of three tons of coal for the first ovens and 22 tons for the modern ovens. In Europe to this day, units of this latter size are entirely unknown.

Just as the first automobile was a thing of worry and a care forever, so the most extraordinary care was demanded in operating these first ovens. The ovens

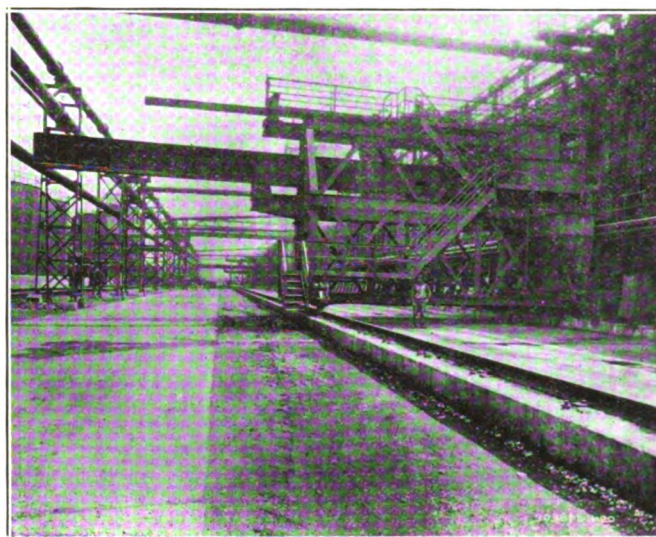


Fig. 3—Modern Semet-Solvay Pusher. Note the height of the machine by comparison with the man standing on the ground.

both of these extremes have been accomplished without difficulty in several Semet-Solvay plants.

Mechanically speaking, the most important improvement has been the substitution of electrical power in the modern plants, which has greatly simplified the problems of power transmission and plant maintenance. Some of the devices adopted on the first plant were most ingenious. One of the most interesting of these was the so-called "compass pipe", whereby steam was carried to the pusher engine. This was made up of short lengths of pipe connected with universal joints in such a way that it would open and close like a folding rule as the pusher moved along the track. The photograph shows the original pusher somewhat remodeled to include a leveling ram, but using the same compass pipe which is still employed on this plant.

The modern regenerators and reversing mechanism as applied to coke ovens, of course, were entirely unknown, no preheating of the air being considered necessary. Even at that time, however, the principles

of conservation of heat were effectively applied and a large part of the heat in the waste gases was recovered in waste heat boilers, which furnished ample steam for operating the entire plant. Since there was no active demand for surplus gas there was no particular incentive toward reduction in the amount of gas required to heat the ovens, which sometimes ran as high as 9,000 feet per ton of coal coked, as contrasted with modern Semet-Solvay regenerator oven practice which requires only about 4,500 feet per ton.

It was very shortly realized, however, that if the gas could be made available there would be no difficulty in finding uses for it, and coke oven engineers began the development of means of reducing the amount of gas required for heating, and increasing the amount released as surplus. Several modifications of the original type of oven resulted from this work, such as the so-called "sole flue" type in which the air entered through passages on either side of the sole flue through which the waste gas left the oven, thus obtaining some small heat recovery. The recuperator

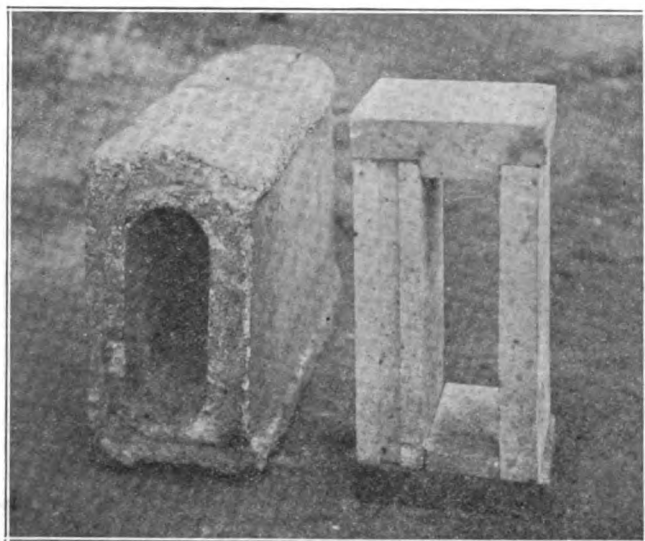


Fig. 4—Comparison between original Belgian tile used for oven linings and modern silica slabs. The Belgian tile, although very strong and heavy did not transmit heat as readily as silica and for that reason was discarded.

oven was another development which has been successfully used abroad, but which has been displaced in this country by the application of the regenerator principle to coke ovens, which has proven more efficient and generally more satisfactory for American usage. This improvement in heat recovery at the ovens has made impossible the use of waste heat boilers since the temperature of the waste gas does not average over 300 degrees C., but the value of the surplus gas released far overbalances the cost of producing steam in a separate power house.

Leaving the ovens the gas was drawn through the old type of tubular condensers to the exhausters. These condensers have since been replaced by the more efficient and much less expensive Doherty washer coolers, which were developed and are controlled by the Semet-Solvay Company. The old type of ring and bell washing and absorbing apparatus for recovery of by-products has also been replaced on the modern plants with apparatus of the grid type, which has proved a remarkable improvement. Yields of 13 pounds of sulphate of ammonia and 4 gallons of tar

per ton of coal charged were considered good in 1893, while the modern apparatus makes possible a recovery of over 25 pounds of sulphate and 8 to 10 gallons of tar.

When the first by-product coke oven plant was built, recovery of light oil was not considered a commercial proposition. In 1900, however, the Semet-Solvay Company erected the first light oil washing plant to be built in the United States, which, it might be noted, is still in operation. The war, with its sudden, imperative demand for light oil for high explosives, brought this particular recovery process into great prominence, with the result that all modern by-product plants are now equipped to make light oil or similar products.

In 1893 by-product coke was unknown in the metallurgical industry and many blast furnace men can still remember the interest aroused when the first by-product coke was used in the old Buffalo Union Furnace, under the direction of Frank Baird. This coke was supplied from the Syracuse Coke Oven Plant

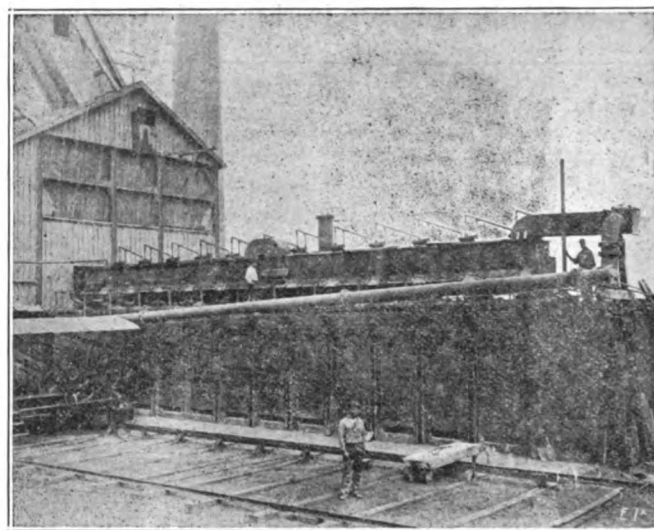


Fig. 5—First by-product coke plant built in the United States. Front view showing coke pusher and original submerged type hydraulic main.

and used successfully in a series of parallel tests in competition with selected beehive coke. In contrast with the modern series of mechanical screens for preparing furnace coke, the original screening station is shown in the photograph of the first plant—a man with a fork and a wheelbarrow.

Since the industry started perhaps the greatest improvements have been made in the method of preparation of the coal before charging. On the first plant the coal from the mines was roughly crushed and charged direct. No attempt was made to pulverize or to mix different kinds of coal. In the course of a few years, however, it was noticed that while certain kinds of coal have a good quality of coke, other kinds of coal of similar analysis seemed to produce a very poor quality of coke, indicating the presence in the first coal of some peculiar principles which were lacking in the second coal. In certain coals, as for example, Pocahontas, it was noted that there seemed to be a superabundance of this peculiar coking quality. These facts were given careful study and numberless experiments were carried out, the whole work resulting finally in the modern methods of mixture and

preparation of coal. At the present time coals are being successfully coked which 25 years ago were considered entirely useless for this purpose, not because

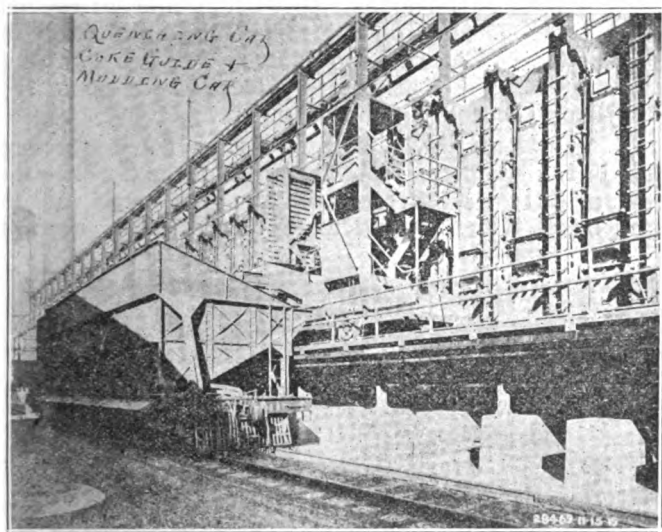


Fig. 6—Modern Semet-Solvay Ovens. Discharge side showing coke quenching car and combination coke guide and mudding car.

of the lack of coking quality, but because of the poor structure of the coke produced, when those particular coals were used alone. Development along these lines is progressing rapidly as the supplies of first-grade coking coal become limited and to an ever increasing extent, these so-called poor coking coals are being used successfully.

Despite all the changes and improvements in the art, the fundamental characteristics of the original Semet-Solvay oven have remained. That these were based on sound engineering principles is demonstrated by the fact that the first plant, after 28 years of uninterrupted operation, is still in run and, though the linings have been replaced at intervals, the oven structure, foundations, main flues and division walls, remain unchanged. The modern Semet-Solvay ovens are the result of 28 years' constant development in meeting new conditions; they operate at far higher temperatures and have greatly increased capacities, but the same simple and efficient methods of heating control are employed, and the same heavy foundations and strong division walls are still integral parts of the construction, and offer the same assurance of long and useful existence and high economies. Perhaps it may be that a quarter of a century hence these "modern ovens" also will be looked upon as milestones on the path of progress.

Jones & Laughlin New By-Products Plant

Members of the Coal Mining Institute of America Visit the New By-Product Coke Oven Plant of the Jones and Laughlin Steel Company in Connection With Their Annual Meeting in Pittsburgh.

ONE hundred and fifty members attending the Coal Mining Institute of America, which was held in the Chamber of Commerce, Pittsburgh, Pa., December 8, 9 and 10, visited the Jones & Laughlin new by-product oven plant on an inspection trip on the last day of their meeting. When they arrived at the plant, they were divided into groups of 15 and furnished with a guide who assisted them throughout their trip. The new plant which consists of five batteries of by-product ovens, 60 ovens to the battery, is located just above the Eliza blast furnaces in Hazelwood, directly across the river from the Southside works.

The coal used in the by-product plant is brought down the Monongahela River on barges of nearly a thousand tons capacity and unloaded at the wharf located at the plant. A chain bucket elevator removes the coal from the barges and delivers it to electrically driven crushers which crush the coal down to two inches in size. From here the coal is still taken to a second crusher where it is crushed so that a large percentage of it will go through a one-half inch mesh screen. Pulverized coal is then taken by means of a plate conveyor which operates at the rate of 10 tons a minute to large storage bins where it is held until charged into the furnaces. Running beneath the storage bin is a track on which runs the large larry cars. This car is built of four conical shaped hoppers which are so placed as to cover the large holes of an oven after the battery has been heated up to its charging temperature. Above the hopper is a tube which

measures the volume of coal unloaded in each hopper. Each car is weighed before being charged. The car is equipped with levers to open gates at the bottom of the hopper when the car is placed over empty ovens.

As mentioned before, the plant consists of five batteries of 60 ovens each, of the Koppers crossed regenerative type. One series of three batteries in a row and the other series of two batteries in a row, these face each other. The ovens are constructed of brick consisting of a number of silica and clay shapes. Silica shapes are used in the ovens and the flues, first and second grade paving brick are used in the tops of the ovens. The batteries are built on a large concrete mat. The brick securely held together with upright beams between the ovens proper, and directly on sides of end flues. These beams are held together by tie rods, having adjustable threads on end of rods to take care of expansion and contraction of the ovens. As a general expansion takes place, special care that the proper adjustments of the tie rods are made must be taken. The ovens generally are rectangular wedge shape and of the following dimensions:

Length	37 ft.
Width, pusher side	15¾ ft.
Width, coke side	18¾ ft.
Coal height	9 ft.
Capacity of pulverized coal.....	12 tons
Capacity of mine run coal.....	13 tons

The average coking time is about 22 hours and the plant is carbonizing about 3,500 tons of coal a day.

The coke when pushed is discharged into iron and steel angle sloping bottom pusher cars, whose length are approximately the same length as the length of the oven. The load in the car is then taken to the end of the batteries and is quenched with water for about a minute. Quenching station consists of two concrete settling basins, a small pump house and a brick hood in which two 12-inch quenching spray pipes are suspended. For each charge of coke about five to six thousand gallons of water are used through this system. The water is furnished by pumps. After the coke is quenched and allowed to stand several minutes, it is taken to the coking wharf where the lower gates

ing through. The joint is placed there to prevent the mains from blowing up, should there ever be a back fire from any individual gas burner, the theory being that joint should blow out and leave the main intact.

The ovens are constructed with 30 flues of the vertical type, 14 flues on the coke side, and 16 on the pusher side. The division is made this way, through the center of the coal charge, and not necessarily 18½ feet from the ends of the oven.

The gas to the individual ovens is run through 1½-inch riser pipes from the fuel gas main on either side of the ovens, through the gas gun, hence into the gun brick, which extend to the center of the oven, to

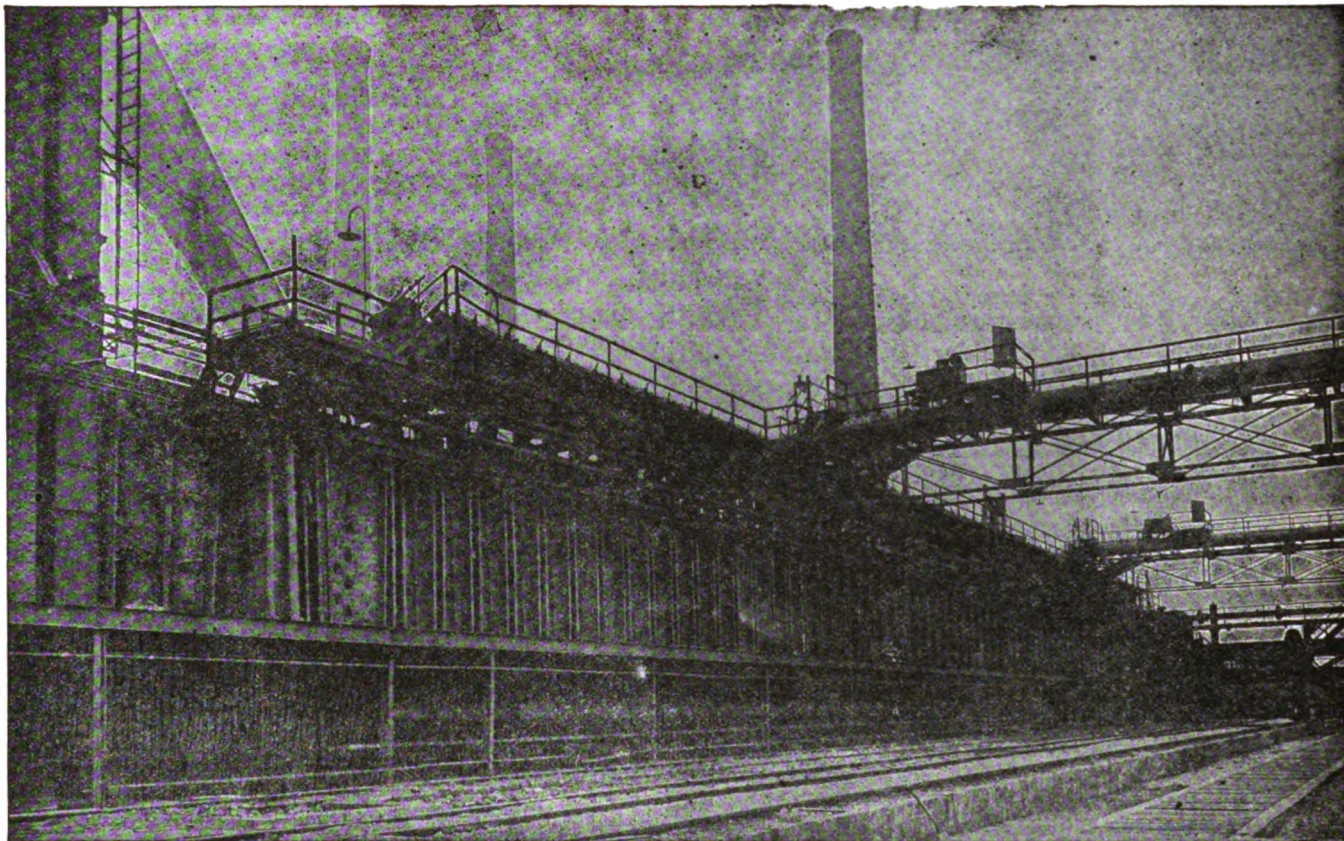


Fig. 1—Battery of triangular flued cross regenerative combination ovens in Jones and Laughlin's plant.

of the side of the dump car are opened by means of air cylinders and receive air from a compressor on the electric locomotives. This forces the coke to slide out upon the wharfs.

Gas Consumption—Ovens.

The fuel gas for the ovens, which is only 40 per cent of the total gas production, proves that present-day operation and construction is far superior to that of five to eight years ago, when 30 per cent of the surplus gas had to be used for fuel.

Method of Heating.

The gas is distributed along each side of each battery by means of an 18-inch steel main, which branches from the stack end of the battery from a single main. The pressure in these mains is controlled by means of valves at the branch header. The extreme ends of the two mains are blanked off by explosion joints, made of two thicknesses of 10-ounce duck cloth, well rod-loaded to keep the gas from seep-

the width of 16 flues on one side and 14 on the other side. The gas passes through holes in the top of the gun brick, in which are set clay nozzles with oval shaped holes. The size of these holes determines the amount of gas burned in each individual flue, provided the tops of the flues have the same pressure, which will be explained later. Setting of nozzles at present is coke side, counting from the outside toward the center.

Coke Side.

No. 1	.3903 sq. in.
No. 2 to No. 12, inclusive.....	.3564 sq. in.
No. 13 to No. 14, inclusive.....	.3905 sq. in.

Pusher Side.

No. 1 to No. 12, inclusive.....	.3564 sq. in.
No. 13 to No. 16, inclusive.....	.3838 sq. in.

As the gun brick is of uniform 4-inch size throughout, the gas heats up while going toward the center of the oven, hence it expands and volume increases. To burn the same number of Btu per nozzle in half

hour, the area must be increased toward the center of the oven. Due to small irregularities in the nozzles themselves, and standardizing as much as possible, it was found that three size nozzles are well adapted to this plant.

Each vertical flue unites into one large horizontal flue, running the full length of the oven over the vertical flues, with round hole diameters as follows:

Coke Side.		Pusher Side.	
	Nos.		Nos.
4¼ inch	1 7	4¼ inch	1 6
5¼ inch	8 14	3¾ inch	9 16

The pressure on each vertical flue is controlled by a brick, called the slide brick, partially over this round opening, the flue being set in the following manner:

Coke Side.		Pusher Side.	
	Wide open		Open
No. 2—5	70 mm	No. 2—8	55 mm
No. 6—8	65 mm	No. 9—16	50 mm
No. 11—14	50 mm		
No. 9—10	55 mm		

This setting is varied a trifle by taking pressures in each individual flue under sliding brick and adjusting the sliding brick one or two millimeters more open or closed. Pressure carried at this point is 3 mm of water pressure, with zero pressure in the horizontal flue. With the pressure in the horizontal flue, there is practically no gas travel between the oven chamber and the horizontal flue which carries the waste gases.

Under each oven, also divided as the oven flues, are the regenerators, through which the waste gases leave the ovens. At the top of these regenerators there are holes leading to each vertical flue, entering the vertical flue 18 inches above the gas nozzle, with a 3-7/16-inch diameter hole, square area 9.28 inches, on end flues, 2-13/16-inch holes, square areas 6.21 inches for the rest of the flues.

Leaving the regenerators, the waste gases pass through a short iron flue, called wind box, leading to the waste heat flue, running full length of the battery on either side, uniting at stack end of battery, and leads through main flue to reinforced concrete, brick lined, 8 feet diameter, 200 feet stack.

In each flue on either side of battery are installed two sets of dampers, one set being motor driven, connected with same machine that reverses the gas. These dampers open and close off completely, communication between one side of the battery with the stack, or the other side, the side on which the gas is burning being closed to stack.

The other dampers are hand operated and are used for giving a certain setting of draft on the battery. Taking the above as an example, the main damper may be opened or lowered, and the pusher side draft raised from 10 to 12 mm, the coke side will then automatically follow from 12 to 14 mm, without regulating the hand or auxiliary dampers.

The wind box leading from gas flue to regenerator, has a hinged lid, which is also operated by this motor reversing machine.

Take a cycle in reversing the gas, which takes 56 seconds. The first movement of this machine cuts gas off from each individual rises to each oven by a mechanically operated cock. It then gives ample time to burn all gases left in the guns and flues, before the air is cut off and reversed. The two reversing dampers then change positions, the one from closed

to open, and the one open closes, the hinged lids on the air boxes at outlet of the regenerator also reverses with the dampers. Thus the air cycle is reversed the last movement of the machine opens the gas cocks on the other side of battery from what it was before reversing. The air then enters regenerator through open lid in air box, preheats while going up through the regenerators, unites with the gas in the individual flues, burns with a flame within a foot of the top of each individual flue. The wasted gases pass up through the openings left by the sliding brick settings, into a horizontal flue to other half of the oven. Each individual flue receiving part of its waste gas, gas travels down these flues, through air ports into regenerator where considerable of its sensible heat is stored, then out through the air box, having hinged lid closed, and into waste heat flue, and hence to stack.

When over 22 hours coking time, it is found convenient to use iron strips, called finger bars, which can be inserted under the wind box lid, whereby restricting the area, thus increasing the air velocity at this point. It tends to carry a greater suction in the flues, so when caps on gas guns are opened when gas is burning on opposite side of battery, air is drawn in and up through the heated nozzle into air ports and out with waste gases. As nozzles get hot, it is necessary at times to carbon out, as termed at the coke plant. This varies from nil to 25 minutes during the half hour, depending upon the amount of carbon deposits in the gun and nozzles.

The damper mentioned in the foregoing paragraph in the short iron flue or wind box, serves the purpose of giving equal draft to each oven. Those at far end of stack being practically wide open; those nearest the stack nearly closed. They are set with gauges, as the irregular installation of the checker brick in each regenerator may vary, due to different men laying the checker brick. At present on the plant the suction of draft carried in each regenerator top is 10 mm water pressure on coke side and 7 mm on pusher side. Gas pressure in 18-inch main on either side of ovens is carried at present on 19 hour coking time, 42 mm pusher side; 48 mm coke side.

Draft in each waste heat flue before entering main flue at stack:

Pusher side	12 mm	Coke side	14 mm
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Waste heat, varying from 230 degrees C. (446 degrees F.) at beginning of half hour to 255 degrees C. (491 degrees F.) at end of half hour. It must be remembered that on the coke side there are only 14 flues, and on the pusher side, 16 flues, although more gas is used on the coke side, as the oven contains more coal to the pusher side, and yet be uniform throughout. On 19 hour coking time we find a temperature of 1,240 degrees C. (2,264 degrees F.) and on 24 hour coking time, 1,095 degrees C. (2,000 degrees F.), necessary in the flues to coke our coal.

The ovens are pushed in the following manner: 3, 13, 23, etc. Next series is 6, 16, 26, etc., the key being, push one series then skip two, namely, 4 and 5, then push the next series. In this manner the heat distribution throughout the battery is more uniformly kept constant than by any other pushing schedule that has yet been mathematically figured.

Effect of Coking Time on Coke.

Indications thus far are that a long coking time is necessary to make good metallurgical coke from the

coal used. This requires less heat, but coal is subjected to a longer but lower heat than with faster coking time. With the construction of the oven, only 1,000 Btu are required to coke one pound of moist coal, as charged to the oven. Older ovens, being wider, require normally 1,170 Btu. In this case, the coke on the outside next to the walls is not so much overcoked as when ovens are wider, and where heat must be driven in at a greater rate of speed. Undercoking, rather than overcoking, produces a better coke, hence we are working along this line at present. By examining a piece of coke, it is readily seen that the end nearest the oven wall has an irregular surface, but the coke itself is more solid, with less pore space than the end toward the center of the oven. Coke being coked from the outside toward the center of the oven, gives the cleavage which is so evident when oven is pushed. This closer grain on outside of coke nearest oven wall is due to gases leaving tarry mass, and leaves the oven by going through the incandescent honeycomb of the mass which has previously been distilled. It is very hot, and raw gases distilling off and coming in contact with this hot carbon, breaks up some of the raw gases and deposits carbon in the cells of the coke, giving it a closer grain. The higher the temperature, the more the gases break up and deposit carbon, not only in the coke, but also on the walls and roofs of the ovens. The breaking up of carbon gas and depositing of carbon is not detrimental to the coke, but it cuts down the capacity of the ovens, also making irregular walls, and causes coke to push hard, increasing from 100 amperes normal load to be as high as 400 amperes on a stickler.

Increasing the heat of ovens, however, makes a very brittle coke, which breaks up very readily when handled.

As coke is graded by its capacity to show a fairly large size after it is dropped six times at the coke plant and several times at the blast furnace, reaching the tuyers in the furnaces under a load, it cannot be emphasized enough that a large hard coke is desired.

Raw Gas.

The raw gases distilled from the coal pass off the outside of the oven, up along the walls and along the top of oven above coal level, and out into the collection main, through the off-take pipe mentioned in a previous paragraph.

The gas in the oven has a pressure of a .5 mm water at beginning to .5 mm suction at the end of coking time. With this pressure very small, and zero pressure in the horizontal flue, very little gas passes through the brick work to either dilute the raw gas or raw gas going to the waste heat flue.

The raw gases carry in them all the tar oils, together with free and fixed ammonia, the different constituents of the fuel gas, benzol and all of its homologues, paraffines, pyridines, and water vapor. High temperatures tend to polymerize benzol to naphthalene.

This naphthalene is detrimental, both as a product to benzol, and in tending to stop up the gas mains, by precipitating out the flakes. It has the property of passing from gas to solid form without passing through the liquid stage. It can, however, be melted. As all products of the coke plant are made in the ovens, the heat treatment is the most important factor in operation.

High heats, however, tend to break up the paraffines, which is present in large amounts, and would

tend to increase our benzol output. As high heats are detrimental to the production of good coke, we are governed by low heats, regardless of recovery of by-products.

The effect of water on coal is very marked. Pulverized coal has its greatest density with 9 per cent moisture. As the coal is charged under 5 per cent moisture we are benefitted only to a small extent in the compressing of the charge. The water vapor or steam given off gives a larger volume of gases and increases the velocity, thus taking off the gas from the hot zones in a shorter period of time, allowing less breaking up of the raw gases and tar.

The liberation of nitrogen in coal is found by experiment and in practice to vary according to several laws, that with different amounts of moisture in coal, different amounts of ammonia are recovered in the same coking time. Increasing the temperature tends to reduce the same coking time. Increasing the temperature tends to reduce the ammonia to cyanides, and is thus lost as ammonia.

Hydrogen sulphide plays an important part in the recovery of ammonia, due to the fact that it oxidizes at as low a temperature as 364 degrees C. (687 degrees F.), while ammonia oxidizes at 800 degrees C. (1,472 degrees F.) to 900 degrees C. (1,652 degrees F.). Oxygen present in coal, occluded, or just as air, depending upon the tightness of the oven and pressure or suction which may be on it at that time, attacks hydrogen sulphide first.

Following is table showing temperatures of different constituents breaking up at given temperatures:

Hydrogen sulphide	360 C.
Acetylene Benzol	429 C.
Ethylene	543 C.
Hydrogen	585 C.
Carbon monoxide	651 C.
Methane	750 C.
Ammonia	800 to 900 C.

Some presence of oxygen is unavoidable, but ammonia is protected by the hydrogen sulphide, leaving ammonia to pass off. By experiment, in this instance, at 425 degrees C., (797 degrees F.), 98.14 per cent hydrogen was oxidized, whereas at 450 degrees C., (842 degrees F.), only 2 per cent of the ammonia was attacked. As hydrogen sulphide gives off sulphur dioxide on oxidation, its effect as a protective agent is not always advantageous, as the sulphur dioxide may not always form the thiosulphate, and under certain conditions corrodes the gas mains.

While giving the advantages of the coal tops on the coke, as far as benzol is concerned, a hotter top is welcome when troubled with paraffines. With cool tops they are not broken up, and contaminate the pure benzol and taluol. When these products are used for motor fuel, paraffines are not so objectionable, but when used for nitrating purposes, the per cent that will nitrate is reduced.

Following table gives gas analysis on 24 hour coking time, samples taken throughout the coking time:

Constituents	Time			
	1	6	12	24
CO ₂	1.4	2.2	2.0	1.4
III	3.5	3.8	2.8	.6
O ₂	1.6	.5	.6	.2
CO	2.6	1.7	1.4	5.4
H ₂	48.5	52.0	57.0	73.1
CH ₄	37.0	37.3	33.4	16.0
N ₂	5.4	2.5	2.8	3.3
Btu	619	638	604	427

The next step is to give an idea of the gas travel from the battery. The gases leave the individual ovens through the 14-inch off-take pipe mentioned at the beginning, into the collecting main, which is of steel structure, flat top and round slanting bottom. There are two mains to a battery, each one-half the length of the battery. Tar and liquor are flushed through these mains, liquor containing about 60 per cent NH_3 liquor and 40 per cent tar. The purpose of this is to wash along any pitch which may tend to deposit in the main. Liquor alone is too cool to cut the pitch, and tar alone absorbs too much of the toluol and solvent naphtha out of the gas. The tar flushing again returning by pipe to hot drain tank from whence it came.

There are two 30-inch off-takes from each battery, discharging raw gas and tar flushing liquor into a common header, where three batteries discharge into one large 54-inch overhead header to the primary coolers, arriving there at 75 degrees C. The gas leaves the ovens at starting of coking time with temperature of 400 degrees C., (752 degrees F.) to 600 degrees C. (1,112 degrees F.) at end of coking time. Temperature drop to collecting main is 300 degrees C., (572 degrees F.) to 325 degrees C. (617 degrees F.). Although the gas above the flushing liquor is hot, the flushing liquor is raised only two to three degrees, while traveling through the collecting main.

At the off-take of the collecting main is another tar liquor spray. Gas travels through this 30-inch main attains a velocity of 16 feet per second, temperature of gas being 150 degrees C. (302 degrees F.) to 185 degrees C. (365 degrees F.).

A butterfly valve is inserted in these 30-inch horizontal off-take suction mains. These valves are operated by two types of gas governors, one of which is electrically operated, the others by means of hydraulic pistons. In both cases, the valves open or close by the position a small gas holder float takes, relative to the pressure in the collecting main.

In order to maintain the beforementioned pressures in the oven, namely, 5 mm water, with the length off-take pipe between oven and collection main that we have, we find it necessary to carry $2\frac{3}{4}$ mm water pressure in collection main. The best regulation that we have varies 1 to $1\frac{1}{2}$ mm above and below the $2\frac{3}{4}$ mm mark, making a variation of 2 mm in good weather and as much as 5 mm on windy days. At best these governors can be improved upon.

Handling of Coke.

Returning to the wharf on which the coke is placed, leaving the quenching car, it is allowed to remain for some time for cooling and final inspection for hot coke, which is quenched by means of small hose placed at intervals along the wharf, coke then being fed to a 42-inch rubber conveyor belt, traveling at the rate of 225 feet per minute. Coke falls on top of grizzly bars, into a coke pocket, giving an angle slope of 48 degrees, then over grizzly bars.

The grizzly bars consist of hardened iron bars, each 24 feet long, of which there are six rows in length and 48 bars wide, having $\frac{3}{4}$ -inch spacing. Hence the coke slides out chutes into cars.

At present no domestic coke is made here. 36.5 per cent of the breeze product is used for fuel at our power plant for the production of steam for the various departments.

Boiler House.

The boiler house consists of eight 500 hp, B. & W. boilers, equipped with Coxes chain stokers, arches in combustion chamber being of the Detrich type; superheaters and soot blowers; feed water heater; two duplex feed pumps; three Kerr turbine driven blowers; Hayes CO_2 recorders and indicating waste heat pyrometers.

Ash is handled by means of a side gate, all steel car, from the boilers to outside ash pit.

The braize is fed to boilers by overhead hoppers, which in turn are supplied by crane bucket delivery.

Treated water is used daily, although city water, and in extreme cases of necessity, untreated river water, may be used.

Service Water Pump House.

The water for the plant being delivered through a looped 24-inch water main from the pump house, located on the bank of the Monongahela river, opposite the plant.

The pump house is equipped with 4 centrifugal pumps of 250,000 gallons per hour capacity each, which discharge directly into the main, thus eliminating the stand pipe.

The pumps are driven by electric motors, receiving the current from the Eliza Furnace Department over a high tension cable. This line also serves the coal handling plant and the sub-station, from which all other ac and dc current is delivered to the various departments of the plant.

INCREASED EFFICIENCY FROM USE OF MECHANICAL RUBBER GOODS.

It has been proven, beyond question, that the application of mechanical rubber goods in the different branches of the steel industry has been brought forcibly to the attention of many operating officials by the proper application of these different commodities; belting, hose and packing; and by the employment of practical engineering practice in installing the correct material to handle the particular condition in mind.

Conveyor belts must be so constructed and compounded that they will retain the natural life put into them at the time of construction for the greatest length of time.

Other important belts in the steel industry are hot and cold saw belts and these have been greatly improved in the last few years. Among the most prominent belts to show greater efficiency during the year were the Matchless and Rainbow belts.

It is not possible to operate an air compressor or a steam engine, or any of the many units around a steel plant or a blast furnace, without employing some kind of packing, and it seems from an extensive analysis that the way a great many concerns are packing these different units is with "some kind" of packing, but we have recently been informed by reliable operators that the method employed by the United States Rubber Company's engineers is to thoroughly investigate the conditions and build a packing for each and every condition that will cover the longest period for a single installation and thereby avoid the troublesome and expensive shut-down and the costly renewals due to the fact that the "Right Packing in the Right Place" slogan was not or has not been seriously considered.

The By-Product Coke Oven Industry, 1920

First Large Battery of Triangular Flue Type Ovens Completed and Successfully Operated During the Year—Special Construction Feature the Installations of the Year.

**By C. J. RAMSBURG,
Vice President, The Koppers Company.**

A NUMBER of notable additions have been made to the by-product coke oven plants in 1920. These are as follow:

By the Koppers Company:

60 Oven battery of triangular flue type at Jones & Laughlin Steel Co., Pittsburgh, Pa.

180 Ovens—Bethlehem Steel Company, Sparrows Point, Md.

150 Ovens—Donner Steel Company, Buffalo, N. Y. Plant completed. Fifty ovens placed in operation December, 1920.

50 Ovens—Birmingham Coke Corporation, Birmingham, Ala.

60 Combination Ovens—Domestic Coke Corporation, Fairmont, W. Va.

100 Ovens—Crucible Steel Company, Midland, Pa.

There are some matters worthy of note in connection with these installations. The 60-oven battery at Jones & Laughlin Steel Company, Pittsburgh, is the first large battery of the new triangular flue type.

No factor of the steel industry is more responsive to progress than is the by-product coking department. None has been more closely followed by steel manufacturers. There remains much to be accomplished in order to successfully coke the different coals common to the United States. Progress has been made in the industry, two special difficulties, mentioned in this article, have been overcome.

This oven has demonstrated conclusively the feasibility of constructing ovens of this type—having the additional advantage of increased strength. The batteries at Fairmont and Birmingham are the first ones of the 16-inch wide type of the Koppers' design placed in operation. The latter, at Birmingham, using straight high volatile coal has successfully operated, making excellent coke and very high by-product yields on a coking time of 14½ hours. The Fairmont battery did not go into operation until very late in the year and has been operating on a very long coking time due to shortage of coal, so that there is little to be said in regard to the 16-inch ovens at that location.

The following plants are in course of construction by the Koppers Company:

Chicago By-Product Coke Company, Chicago, Ill.—100 Triangular Flued Combination Ovens.

Dominion Iron & Steel Co., Sydney, N. S.—60 Triangular Flue Ovens.

Milwaukee Coke & Gas Co., Milwaukee, Wis.—150 Triangular Flued Combination Ovens.

One of the most interesting events of the year in Koppers' plants is the operation of the combination oven battery at Providence throughout the year with producer gas made from coke. The operation has shown the complete success of this type of oven which

can be changed over from coke oven gas to producer gas at will, or any proportion heated by either gas at the same time. By this means the output of coke oven gas can be varied from 100,000 cubic feet per day per oven, to 170,000. With the great demand for gas in steel plants this type of oven, with producers using small coke and breeze or any other cheap fuel, promises to be of great importance. This type of oven can be heated also with blast furnace gas.

It has been customary in the past to build Koppers ovens with a coal mass height approximately 8 feet 10 inches. It is interesting to note that the combination ovens to be built in Chicago will have a coal mass height of 10 feet 8 inches, thus increasing materially the capacity of the ovens. Since height of oven can be secured with the least expenditure of money, this means a cheapening of the cost of ovens per ton of coal coked per day and will be an important step forward.

The Semet-Solvay Company has placed in operation the following plants in 1920:

Lackawanna Steel Company, Buffalo, N. Y.—60 ovens.

Sloss-Sheffield Steel & Iron Co., Birmingham, Ala.—120 ovens.

This company has under construction a battery of 80 ovens for the Cambria Steel Company, at Johnstown, Pa.

The American Coke & Gas Co. have completed a portion of their 80 oven installation at East St. Louis, and the remainder will shortly be placed in operation. This oven, planned especially to coke the mid-continent high volatile coals, will be watched with considerable interest, since large claims have been made as to the results to be achieved. Nothing has yet been given out as to the results to date.

Reviewing the year from an operation standpoint, the fact stands out very strongly that those steel plants having by-product coke plants have been in a very strong position compared to those depending on bee-hive coke and gas producer operation. At no time has the benefit of a constant supply of standard coke and a supply of high grade gas been of such great moment. With the slowing down of the steel industry at the end of 1920 and the beginning of 1921, and a closer margin of profit necessary to continued operation, those plants having by-product coke plants will do business while those without will curtail production.

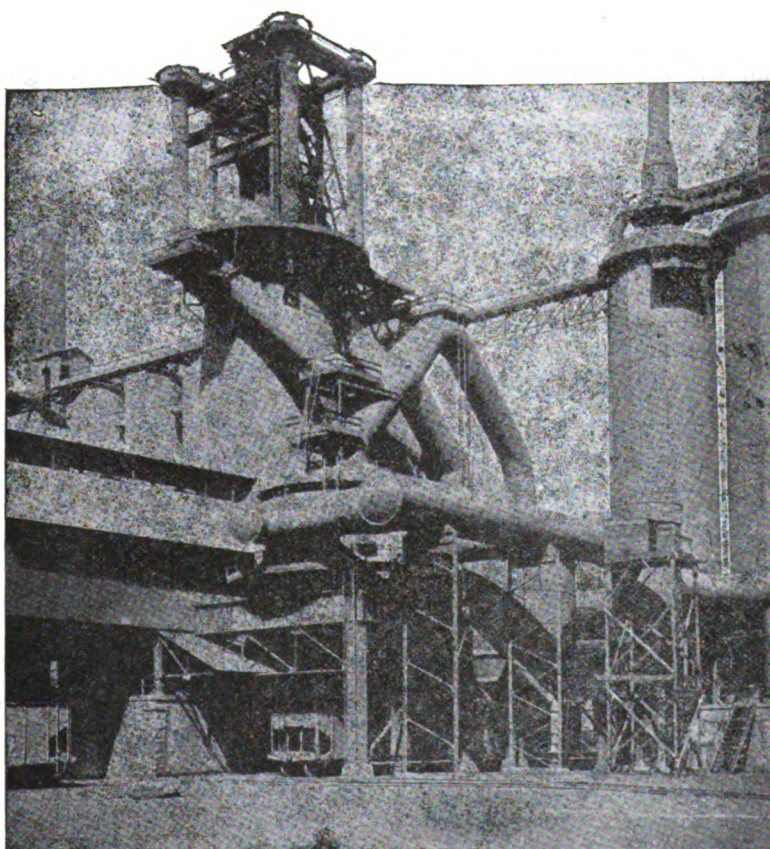
There are signs that 1921 will show considerable activity in coke oven construction, brought about not only by the further appreciation of their necessity in the modern plant, but by a lessening of the cost of construction. In no business is the thought that "in times of depression prepare for times of activity" so clearly realized as the steel and iron industry, and in no plant improvement can this be so clearly realized as in the substitution of efficient saving in coke making.

Blast Furnace Department

Blast Furnace Developments During 1920
By HARVEY W. LINHARDT

Covington Furnace at Low Moor Remodeled
By LOUIS W. HARTWICK

Rough Cleaning Blast Furnace Gas
By A. HUTCHINSON AND E. BURY



Blast Furnace Developments During 1920

Improvements in Blast Furnace Design—Hot Blast Stoves—Boiler Plants—Blowing Engines—Furnace Appliances and Gas Cleaners—Year Not Up to the Record in Production.

By HARVEY W. LINHARDT.

Asst. Supt. Blast Furnaces, Inland Steel Company, Indiana Harbor, Ind.

THE past year in the iron and steel trade has been an adjustment toward normal conditions. The year has not been one of record output in the steel industry due to many adverse and outside influences. Aside from a shortage of semi-skilled labor, the worst feature within the plant operation has been the indifference and inefficiency of the available labor. The truth of the matter is that labor has been working shorter hours, producing less in return for their wages, and has insisted upon being paid more than they were ever paid for doing considerably less than they were accustomed to do. This can only result in an unnatural and unjust relation between employer and employee. However, there are apparently two correctives at hand. One is the rapidly growing movement of the open shop among the steel fabricators and allied industries and which undoubtedly will be reflected to a greater or less degree in the future among the larger iron and steel producing industries. The other corrective is the rapidly increasing tide of immigration of the more permanent type to this country. When the condition is reached of having more men available than jobs, we can look for increased efficiency in labor. This condition has been initiated by the fact that decreased demand for certain steel products has forced the laying off of sufficient men to noticeably improve the working attitude of the rank and file in the steel trade. From a material standpoint one of the chief factors that have seriously affected the continual operation of the industry during the past year were the coal strikes, necessitating the pooling of coals, resulting in inferior coke for those furnaces that were able to obtain coke—the use of domestic size for blast furnace fuel where the supply of coke was limited, and the banking and blowing out of furnaces where no coke was obtainable. The car shortage during the year has been another factor in curtailing output. An ore shortage that threatened many of the independent and inland furnace companies during the year was relieved before the close of the ore season. However, with the major portion of the past year's operative difficulties apparently coming well into hand at the close of the year, the matter of price adjustments should reach some degree of permanent settlement before the winter is far advanced, resulting in an economically healthy and efficiently active condition of the iron and steel trade in the near future.

Blast Furnace Design.

Under the subject of furnace design, this year's development has brought forth no radical departures over what was in vogue last year. The revolving tops are still advocated by many who consider them a sort of universal specific for correcting all distribution evils. In an effort to reduce flue dust production, the high risers and off-takes have come into very general use although they would be a very decided operating disadvantage if they returned fine dust to the furnace and deposited it in heaps that would seriously impair the proper distribution of

raw materials. Late innovations for reducing flue dust production are Kennedy's combination of a pair of high risers to one offtake, and the installation at Lorain with good results of the multiple downcomer construction similar in idea but not carried as far along or as fully developed as the plan proposed by Atcherson at Inland Steel. The object in the case of the high risers being increased gravity effect upon the dust particles and in the other case reduced gas velocity. The maximum angle of deflection of inwall is sought and the linings are of medium thickness. The use of stack cooling plates is receiving little attention outside of the Carnegie Steel Company furnaces. For a number of years, 15 and 16 tuyeres were thought to be the correct number required in blowing a furnace. This later was changed to 12 tuyeres, the number in most general use today. However, the most recent practice in new installations considers 9 or 10 tuyeres sufficient for ample penetration and distribution of the blast. One operator in the East is using eight 7 inch tuyeres on a large furnace with good results. Both plates number 9 to 12 rows, depending upon the height of the mantle, the majority of operators preferring a minimum number of rows consistent with adequate cooling. The bosh angle is generally over 80 per cent. Mohr at Rankin, Pa., is operating one furnace with good results on a bosh angle of 84 degrees 17 feet. Also, Mississippi Valley Iron Company at St. Louis has a smaller furnace with 83 degrees 30 ft. bosh angle. The large hearth of 20 ft. 9 in. that Mathesius originated at South Chicago has been duplicated there in rebuilding one of the other furnaces. On the other hand, Diehl at Duquesne is rebuilding four furnaces with 16.5, 17, 17.5 and 18 ft. hearths. At the fall meeting of the American Iron and Steel Institute Mathesius read a paper on the "Blast Furnace Hearth." Atcherson in discussing this paper contended that the larger tonnages attributed to the large hearth were really obtained from the larger bosh area. This subject should bring forth further written discussions because of its vital importance to furnace production and design.

Foundations.

In keeping with the general trend of economy in construction, the most outstanding feature is the matter of concrete foundations. The heavier massive foundations are being replaced to advantage by lighter but well reinforced skeletonized sections. In this connection might also be mentioned Green's innovation of reinforced concrete substructure for pig machine to eliminate the rapid corrosion from steam and water of the heretofore customary steel substructure.

Hot Blast Stoves.

The question of the proper number of stoves for a single furnace is largely determined by local conditions and the opinion of the management. While three stoves of modern type and structure are generally accepted as the requisite number, a fourth stove is a decided advantage in case of stove repairs or where it becomes neces-

sary to use a poor grade of coke over a protracted period. Two furnace plants are usually equipped with seven stoves, one of which can be used on either furnace. Past troubles experienced in the failures of stove linings have been more pronounced this year. A number of stoves had to be repaired but in most cases it was only necessary to replace a few feet of top checker work and exposed walls in the combustion chambers where the brick spalled badly. This trouble has been generally attributed to inferior quality of brick produced under war pressure.

Boiler Plant.

In addition to the decided trend toward the larger units, high steam pressure and superheat, we find that the construction of blast furnace and mill boilers is working more and more toward the power house type by recent installations of boilers with provisions for firing two classes of fuels. The gas burners being located at one end and automatic stokers for solid fuels on the other end. All fittings are for high pressure throughout. There have been a number of improvements and modifications on gas burners developed during the past year. The Lorain Engineering Department has developed and installed a balanced draft valve on the gas burners at the boilers, to regulate the gas mixture for proper combustion. The results are very gratifying. Several other plants are now making similar installations of other designs. At Eliza and Duquesne, the latest boilers are equipped with burners using forced draft supplied by fans, with automatic regulation of gas mixture producing wonderfully uniform combustion. At Duquesne, they are also using forced draft on the gas burners of two stoves. Further, Duquesne is operating half its new boilers on wet washed gas and half on raw gas. Water softening plants for boiler purposes are rapidly coming into more general use. Higher boiler efficiency coupled with lower repair maintenance and operative boiler costs have warranted their installation.

Gas Mains.

Worthy of special mention is a digression from the general method of conducting gas through overhead gas mains, that is being inaugurated by the Trumbull Cliffs Iron Company at their blast furnace plant at Warren, O. In the boiler house, the gas main is located at low elevation above yard level outside of the boiler house. From the gas main, smaller cross pipes carry the gas over and up through the general boiler house floor level to the gas burners above the floor. Placed in the cross pipes are gate valves for shutting off the gas in the boilers in case of repairs or cleaning. This arrangement of the piping also provides the opportunity for an individual water seal to each boiler by filling the cross main with water, thereby furnishing additional safety during repairs to the boilers. The chief benefit derived from this location of the gas main is the elimination of the disagreeable underfoot water and sludge conditions that are always attendant with overhead gas main washing. The gas main placed in this fashion forms an ideal location for direct flushing to sewers. Other attractive features of this location of the gas main are the increased facility for installing underground ash conveyors and the additional overhead clearances provided, both in the boiler house and around the stoves.

Blowing Engines.

The efforts of the builders of turbo-blowers to develop a dependable machine are being rewarded by the ever increasing favor with which the turbo-blowers are meet-

ing from blast furnace operators. In some cases, the turbo-blowers are preferred to gas engines; the only provision being a constant 250 pound steam pressure and reliable vacuum. The second choice appears to be the high speed reciprocating steam engine, although with the high price of coal which has apparently come to stay, the gas blowing engine will undoubtedly come into its own as soon as its cost has come down somewhat.

Iron Ladles.

In keeping with the general effort to reduce operative costs around the blast furnace, a considerable advance has been made in cutting the skulling loss, maintenance and repairs to iron ladles. This has required several years of designing and building, but the returns have well repaid the effort. At Portsmouth, O., an elliptical shaped open top ladle is used for handling the hot metal. This ladle, built by the Pollock Engineering Company, is of 75 tons normal capacity and is used to pour direct into the open hearth charging ladles, thereby acting as a mixer. These ladles have held 90 tons for a period of six hours with good success but the usual practice is 75 tons held up to four hours. Eliza is using a ladle shaped like a football of 80 tons capacity, built by the Treadwell Company. These ladles have a 13 inch ganister block lining, and have handled as high as 50,000 tons on a lining. The Pugh type of hot metal ladles, manufactured by Treadwell Company are being provided for a number of blast furnace plants now in course of construction or rebuilding. The Pollock Company has designed a cylindrical shaped hot metal ladle of 100 tons capacity that offers all the advantages of a small mixer on wheels. There is also a tendency to replace the truck and frame castings by structural shapes to relieve excess weight and facilitate repairs.

Furnace Appliances.

Under the caption of furnace appliances, the most prominent are probably the Mullen Automatic Drilling Machine, the Berg Automatic Gun, and the Bates Cinder Bott. These machines were all designed with the idea of saving labor, promoting more regular furnace operation and reducing hazards around the blast furnace. A willing and intelligent use of these machines will in a short period pay for their installation in time saved in operation.

Stock House.

The handling of the furnace raw materials in the stock house has had very little change from a mechanical standpoint over what was prevalent last year, except in those cases where the operative management favors the mechanically operated bin gates. The one feature however, that has of necessity called for attention, has been the removal of the coke breeze from the stock house. The old methods of disposing of the largely increased amounts of coke breeze due to inferior coke, this past year, are rapidly becoming obsolete because of prohibitive costs. We may say that at no time has it been as necessary to thoroughly screen the coke between the bins and the skip cars, as at the present time. Some furnace operators claim that it is absolutely necessary to take out some of the small coke in order to insure the removal of all of the dust, rescreen and return the small coke. When this practice is resorted to, they usually handle 10 to 12 per cent of the coke as dust and domestic, returning about half that amount as a substitute for the regular sixes furnace coke. This practice has the disadvantage of returning the small coke in skip loads, thereby charging too large amounts for a regular mixture.

Weirton gets away from this by charging the small coke from a special bin through the scale car in regular intervals and small quantities. At Eliza and Edgar Thomson Works, the coke dust is well removed without requiring rescreening to recover the small amount of domestic coke. This is accomplished by the use of wire mesh screens of $1\frac{1}{4}$ -inch square openings, constructed of $\frac{3}{8}$ -inch wire. When the coke is not rescreened, the additional cost is due to removing the excessive coke dust from the skip pits to railroad cars on the general yard level. This cost often exceeds the total labor for charging all the regular materials into the furnace. Quite a number of plants handle the coke dust with a suction system, either a steam syphon and condenser or suction fans; but in either of these systems the power cost is high and the abrasion of the pipe work makes it a very expensive proposition. Much better results are obtained either with automatic skips or bucket conveyors discharging into a continuous belt and from there into a bin elevated above the yard level.

Gas Cleaning.

This subject and its ramifications is one of unending interest, not because of its intricacy but because of its elusiveness. Each year brings forth new attempts and new devices for solving this problem, and the past year has been no exception. The three prominent classes of cleaners, as yet, are the wet washing, dry cleaning and electrical precipitation. The electrical precipitation known as the Cottrell system, with its rather recent companion of English extraction, known as the Lodge system, is rapidly working out of the experimental stage. In reviewing the dry cleaners, and by dry cleaners we refer to the steel wool type as being accepted the most complete in their line, we find that they also are still not fully and reliably developed. Counting the experimental cleaner at Ohio works in Youngstown, the steel wool pad has been in existence about four years and we may safely say that no standard has been reached yet. New devices of this type have been brought out by G. W. Vreeland at Mingo Junction, who has designed a steel wool pad tower type dry cleaner. The dust is knocked from the steel wool pads by a series of hammers instead of by the usual shaking or oscillating motion. The dust is piped to the outside of the shell to be nugged for future use. F. R. McGee, of the Mingo Junction Works, Carnegie Steel Company, has patented a new type of dry cleaner, wherein the gas is drawn from the central part of the tower through a multitude of tubes having a small casting at the end, designed to give the gas a tangential swirling motion as it passes through the tubes. The extracted dust is then collected in one compartment while the cleaned gas is sucked through a separate outlet by means of fans. In an experimental way, high efficiency is claimed for this device. Its practicability remains still to be demonstrated. While not discouraging any efforts along the lines of dry cleaning, sight of the fact must not be lost that the successful operation of dry cleaning, if it is evolved, is not complete until the extremely fine dry dust is properly disposed of. On the wet washing, there has been considerable improvement. South works obtains the remarkably low differential of 2 degrees between the temperature of the intake water of the gas washer and that of the washed gas, by an adjustment of spray nozzles and their positions requiring less volume of water. This is an important vantage point, proving an excellent distri-

bution of gas and water throughout the wet washer and it enhances the constant, uniform, and positive results that are obtained from wet washing. Unquestionably, the tower type of wet washers, like the Brassert, Diehl and Steinbart, are far more effective and reliable than any of the dry cleaning devices that are before the trade today. In connection with wet washing, the sludge is being successfully recovered by means of the Dorr Thickener. This recovery is then mixed with dry dust from the dust catcher in a pug mill either at the dust catcher to avoid handling the hot dust in cars or at the ore field where the discharge from the pug mill might be handled to better advantage. The pugging revolves itself into two different propositions to get the required moisture content in the put mill output. Either part of the Dorr Thickener sludge is added to all the dust catcher dust increased by the proper amount of dust from the stock pile. A further suggestion has recently been brought out and arrangements are being made at the Inland Steel Company plant to determine the practicability of washing all the dust catcher dust to the Dorr Thickener with the discharge water for the gas washers. In case it is desired to return all the flue dust to the furnace without sintering or briquetting, it would only be necessary to use a continuous filter beyond the Dorr Thickener. This would leave the filter cake for recharging raw. It is possible that the above procedure has in it the elements of the future concentration of our iron ores. That this will some day be necessary is strikingly indicated by the decreasing iron content of our iron ores each year.

In closing this review, the writer wishes to pay tribute to the wonderful progress that has been accomplished by American blast furnace engineers and operators who have striven so earnestly and succeeded so well in obtaining recognition of the supremacy of American standards and practice in this greatest of industries.

LAKE SUPERIOR ORE SHIPMENTS IN NOVEMBER.

Iron ore shipments from the Lake Superior region in November were 5,305,738 gross tons, as compared with 3,152,319 tons in November, 1919. This is an increase of 2,153,419 tons, or 68.31 per cent. The season's shipments to December 1, this year, have been 58,428,080 tons, as against 31,130,733 tons to December 1, 1919, an increase of 11,297,347 tons, or 23.97 per cent. The following table gives the November and season shipment by ports and the corresponding figures for 1919 in gross tons:

The Duluth percentage this year to December 1 of 26.49 per cent is considerably less than a year ago, when it was 35.69 per cent of the total. The Great Northern dock at Superior is credited this year with 21.71 per cent of the total, against 19.30 per cent a year ago.

	November 1919	November 1920	To Dec. 1, 1919	To Dec. 1, 1920
Escanaba	483,046	791,130	4,936,968	7,305,457
Marquette	251,149	298,011	2,132,935	3,415,108
Ashland	527,176	726,985	5,915,383	8,174,182
Superior	615,903	1,240,661	10,809,693	14,812,398
Duluth	875,584	1,390,003	16,821,209	15,479,334
Two Harbors.....	399,461	858,948	6,424,545	9,241,601
Total	3,152,319	5,305,738	31,130,733	58,428,080
Increase		2,153,419		11,297,347

Covington Furnace at Low Moor Remodeled

Redesigned Furnace of the Low Moor Iron Company at Covington, Virginia, to Suit the Problems of the Southern Pig Iron Manufacturers, Now in Full Operation.

By LOUIS W. HARTWICK,
Engineer, Low-Moor Iron Company.

IN the design of a blast furnace the engineer must consider all the elements that enter into the production of pig iron at that plant, such as labor conditions, the cost and quality of the ore, the fuel, and the interest and depreciation on the investment.

The problem confronting the pig iron producers of Virginia is very peculiar. They no longer are blessed

so that the construction work would not exceed a reasonable cost, and still eliminate excessive labor costs in production.

This furnace is located on the outskirts of the City of Covington, on the Chesapeake & Ohio Railroad, in Allegheny county, Virginia, and is eight miles west of the main plant of the Low Moor Iron Company at Low Moor.

The native ores used come at present from three mines. One of these mines is within two miles of the furnace, and this ore comes from the mines to the furnace bins over their own tracks. All the ores run about 40 to 45 per cent iron in the natural state and from 15 to 20 per cent silica.

The coke will come principally from the company's ovens at Kay Moor, W. Va. All coke used is beehive and is of a very excellent quality.

The improvements made consist of a new shell above the mantle, and a complete lining, including hearth bosh

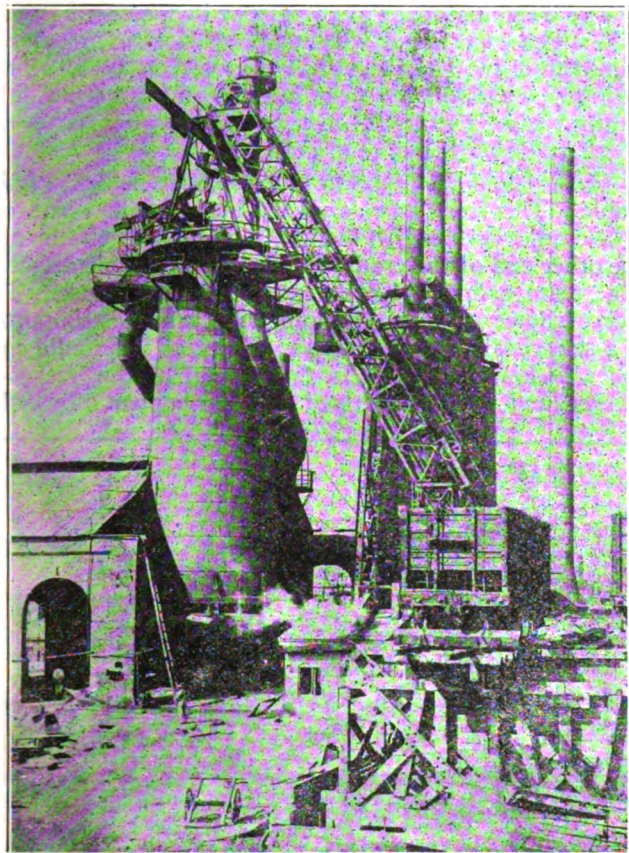


Fig. 1—Side view of the remodeled furnace.

with cheap labor as in times past, as they also must meet the new labor problems, the same as producers in other parts of the country. This new labor condition calls for equipment which will eliminate unskilled labor as far as possible.

On the other hand, however, the native ores are lean in iron and very high in silicious matter, which calls for other ores relatively higher in iron and also carrying more aluminum, so as to get a suitable slag. Thus they are not justified in making as extensive improvements as producers locate more favorably to a richer ore supply.

Bearing these conditions in mind, the Low Moor Iron Company of Virginia, in remodeling their Covington furnace, aimed to make all the designs simple, yet effective,

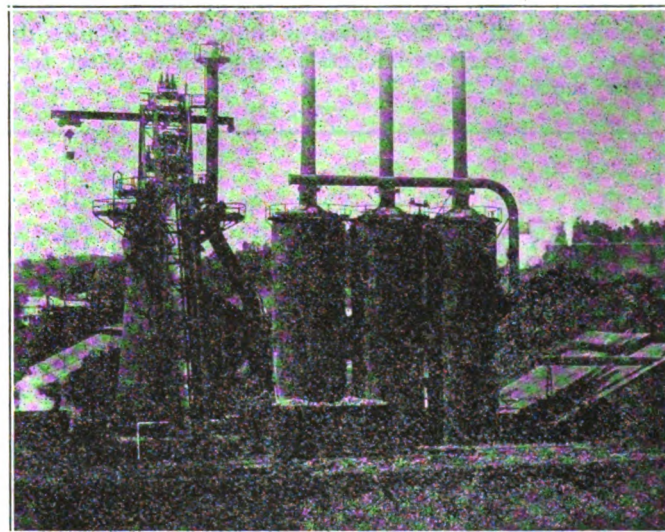


Fig. 2—General view of the plant.

and tuyere jackets, new bins, charging apparatus, hot blast main with valves, and also the re-erection of three Weimer Blowing Engines, removed from the Low Moor plant.

The new shell is built on the old columns and mantle. All the old bosh was torn out and a new hearth jacket of steel plates installed. This jacket is cooled by cast iron cooling plates. The tuyere breast is of steel plates and the bosh is of the design common in the South; that is, a steel jacket cooled by spray pipes, but also provided with louvers to hold the water to the plate. This style of bosh was retained in the new design because of the fact that the cooling water carries considerable organic matter which would cause trouble in copper cooling blocks.

Hearth diameter, 12 feet 6 inches.
Bosh diameter, 16 feet 6 inches.
Stock line diameter, 12 feet 0 inches.
Bell diameter, 8 feet 6 inches.
Total height, 75 feet 11½ inches.
Bosh angle, 78 degrees 40 inches.
Inwall taper, 1 inch in 12 inches.
Tuyeres are 8 in number.

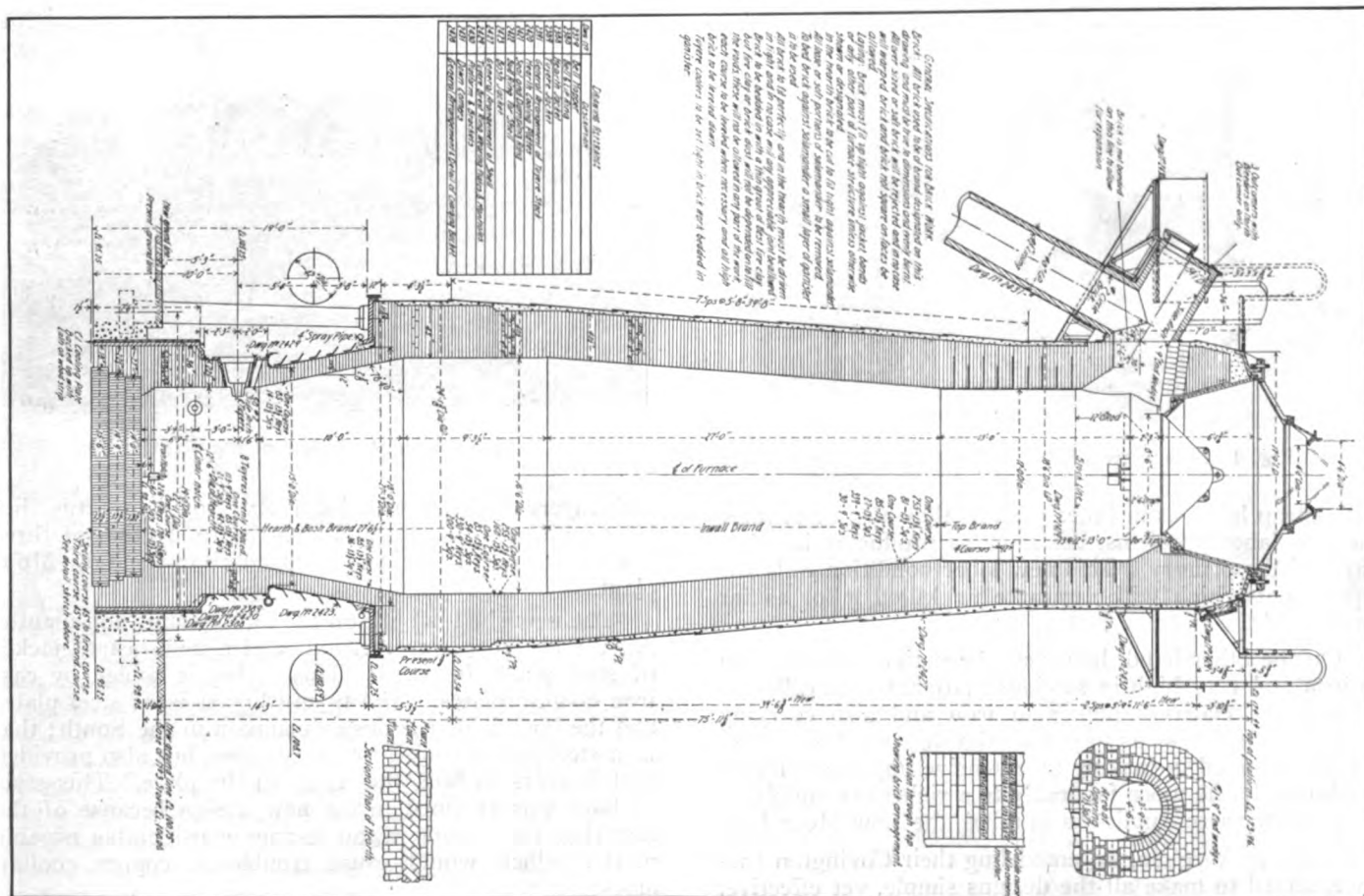
The stack is provided with three 48 inch downcomers, all entering the old dust catcher. This arrangement was chosen as one downcomer took the same place as the original downcomer and the other two arranged so that the outcomers are 120 degrees apart.

The bins are of the W type, with the chutes pointing inward from the two outside slopes. This is with the object of getting proper distribution without any rotating or other complicated devices, as the action of one chute is counteracted by the opposite chute. The chutes discharge into charging buckets passing on a center track below the bins.

In order to keep this design simple, we did not use any form of rotating tops or any rotating devices, and as skips will not properly distribute stock unless there is some form of distributing apparatus used, it was decided to use the Neeland bucket. This device, properly charged, which can be done with the W type bins, gives almost perfect distribution.

The weighing of the stock is done by means of a track scale. The coke is not weighed. An electric locomotive is used to draw the cars, which run very easily, as all are equipped with roller bearings and run with very little friction; also, the tracks are graded down towards the bridge by one-half per cent grade.

The method of dumping the bucket is new and quite simple. The front wheels of the bucket trolley run out on a cradle, one end of which is pivoted to the bridge. The other end of the cradle is lowered by a cable attached to a steam cylinder, located near the hoist house. The bucket is lowered onto a dumping ring, which is supported on a seal ring above the hopper. Thus, as the cradle continues to lower, the bell in the bottom of the bucket is lowered and stock is dumped into the hopper. In order



to seal the top when the large bell is lowered, the bucket is lowered to the dumping ring only, keeping the bucket bell closed until the large bell has been lowered and is again in position; thus the flow of escaping gases is checked while the large bell is down.

Another feature of the design is the operation of the large bell, which is held by two walking beams. These in

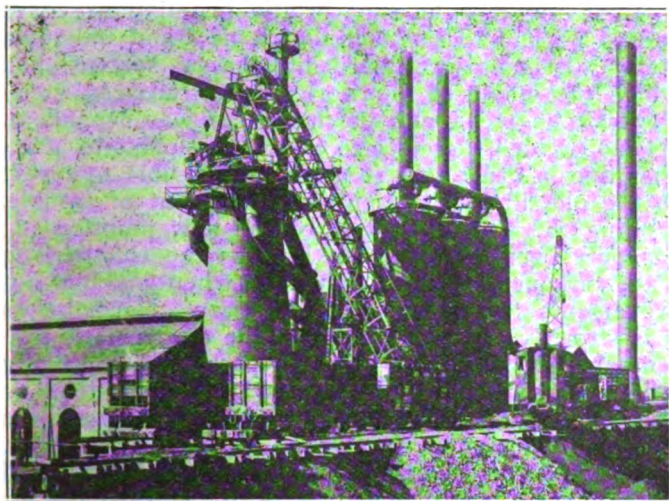


Fig. 3—Unloading raw materials at the Covington furnace.

turn are connected to a steam cylinder by a straight line link motion. Also, the construction is such that should a steam line break, or the steam for any reason be turned off from the cylinder, the bell will remain closed.

In order to provide against renewing parts as much

as possible, and to reduce friction to a minimum, all main sheave wheels are provided with Hyatt roller bearings, as are also the bucket trolley and bucket trucks. In these latter the bearings are mounted in quills made of extra heavy pipe.

To facilitate construction work, and also to handle repairs on top of the furnace in the shortest time, an outrigger supported on a head frame is provided. On this outrigger rides a trolley, supporting a hoisting block. This block is supported by a two-part rope running over a sheave. The hoisting end of the cable is attached to a steam hoisting engine. This rigging is always kept in working condition.

The plant at present is equipped with three 18 ft. Gordon-Whitwall three pass stoves. However, it is intended to add another stove in the near future.

The steam plant consists of four B. & W. boilers of 250 hp each, a National boiler and one Meehan boiler. The blowing equipment consists of one Allis-Chalmers 42x60x80 and three 36x48x72 Weimer blowing engines.

The Frazier-Sheal Company, of Cleveland, O., were the engineers in charge of these improvements, which were under the direct supervision of Louis M. Hartwick, who also invented and designed this arrangement for charging the furnace. All castings and machine work was furnished by the Covington Machine Company, of Covington, Va. The King Bridge Company of Cleveland, O., fabricated the skip bridge and head frame. McAllen Bros. of Pittsburgh, fabricated and erected shell jackets and downcomers. The brick used in the reconstruction was furnished by the Ashland Fire Brick Company. All construction work, except shell and jackets, was done by the Low Moor Iron Company of Virginia, by their own mechanical force.

Rough Cleaning Blast Furnace Gas

Lodge Electrostatic Process of Cleaning Blast Furnace Gas as Used at Skinningrove Plant Built as a Result of the Experiments Made From the Discharge System as Invented by Sir Oliver Lodge.

By A. HUTCHINSON and E. BURY.

IN the design of the large-scale plant, very little data existed as a guide beyond the vital importance of carefully regulated gas and electric flow and a maximum speed limit of gas flow of three feet per second. Furthermore, there was no standard degree of gas cleaning which could be fixed to guarantee clean stoves, boilers, and checkers. In determining the size of cleaning plant to be employed, it was for obvious reasons desired to keep the capital expenditure within the limit required for rough cleaning, bearing in mind that the Theisen plant for the gas-driven power station at the works was already in existence and would always have to be employed to wash and cool the proportion of the gas required for that purpose. All that was necessary, therefore, was to clean the gas adequately for stoves, boilers, and other furnace work, and for these purposes 0.3 gramme of dust per cubic meter in the cleaned gas was ultimately fixed as an arbitrary standard. Recent investigation at Continental works, where rough water washing for stove and boiler use is almost universally

employed, has shown that the desired end can be obtained by a higher dust content in the cleaned gas, instances being on record where stoves had not been cleaned for five years with a dust content of approximately 1.0 gramme per cubic meter in the water-washed gas. The arbitrary standard of 0.3 gramme per cubic meter was therefore well on the safe side, and there would be no point in increasing the capital expenditure on plant with the object of reducing the dust in the gas to below that figure, so far as boilers, stoves, and furnaces were concerned. Since the start of the full-sized electrostatic plant at Skinningrove last Easter, the dust content has been reduced from 5 to 6 grammes per cubic meter in the raw gas to 0.8 to 1.1 gramme in the cleaned product, at which figure no deposit of dust has taken place in the flues since the plant started work. It should be specially mentioned that this result has been attained with 15 to 20 per cent of the electrostatic plant out of action owing to difficulty in obtaining electrical equipment, spare transformers, etc. With the complete plant at

work it is expected to maintain the dust in the cleaned gas at 0.5 to 0.7 gramme per cubic meter, which will serve amply the purpose for which the plant was erected.

In the foregoing reference has been made to the vital necessity of carefully regulated gas flows as being essential to successful electrostatic treatment—a statement which demands great emphasis. It has to be remembered that in this method of gas cleaning the gas passes without restriction of any kind through nests of rods and plates, which are perfectly open and offer no resistance to the gas as in the case of filters or powerful sprays of water. The danger of gas slipping through the treatment chambers uncleaned is therefore much greater in electrostatic methods than is the case with water-spraying or filtration plant. Recognizing this difficulty, the electrostatic plant at Skinningrove was designed to split up the gas make and flow through 16 cleaning units further subdividing the flow in each chamber through adjustable bafflers, so that the gas would flow evenly over the discharge grids both in horizontal and vertical planes. As a further precaution the inlet of each chamber was designed so as to deliver the gas equally over the vertical and horizontal planes of the discharge surfaces, a similar arrangement being adopted at the chamber outlet in collecting gas for delivery into the clean gas main. It was elected to regulate the flow of gas through each chamber by adjusting the outlet valve which, being clean, would not clog up and upset the gas flows.

Of equal importance is the equalization of the electrostatic field throughout the chambers, since any short circuiting would militate against equal treatment of the gaseous atmosphere. The Lodge Fume Company, who are responsible for the electrical equipment of the plant, have provided against this eventuality by supplying each chamber with two sets of discharge grids in series, each with its own transformer set. Each set of grids is provided with 7,000 discharge points, that is 14,000 points to each chamber, so the electrostatic field is as evenly distributed throughout the chambers as conceivable. Short circuiting has taken place from time to time, but has invariably been the result of irregular cleaning of the grids: such difficulties will disappear as the practice becomes standardized.

The authors regard the above considerations as of utmost importance in the successful application of electrostatic methods to cleaning blast-furnace or any other gas.

Fears have been expressed in some quarters, indeed at last year's September meeting of this institute, that the risks of explosion were great in passing electric discharges through a combustible gas, in the event of sparking. This would certainly be the case if the gas were mixed with air so as to provide an explosive mixture. It so happens, however, that the whole system is under pressure from the furnaces, and air admixture is impossible unless minus pressures are incurred. Against the latter eventually there has been provided an automatic switch which cuts off the discharge in the event of dangerous minus pressures. Under no circumstances has an explosive condition been approached in the main system, although care must be exercised when "bleeding out" individual chambers (i.e. replacing gas by air for cleaning purposes) to cut off the electric discharge. Through neglect of this precaution a few weak ex-

plosions have occurred, which, however, were perfectly harmless.

Layout and Construction.

The construction of the plant has been dealt with very fully by Mr. Arnold Burry, engineer in charge, in a further section of this paper, but the following points require special emphasis.

In laying out the electrostatic installation regard had to be had to the fact that a new and unknown factor was being introduced into the gas system upon which the whole of the works (blast-furnaces, steel-works, coke-ovens, and power-house) was dependent. It was decided therefore to attach this plant to a by-pass flue in order that it might be possible to revert to the old dirty gas supply in the event of trouble, pending the standardization of the new practice. It has only been necessary to by-pass the electrostatic plant on one occasion, that was when making improvements to the dust-removal gear. Nevertheless it is strongly recommended that the electrostatic system should be placed on a by-pass flue, especially where all sections of the works are independent, as at Skinningrove. To make this policy complete, flues and pipe connections have been built so that stoves, boilers, and power gas-washing plants can be supplied instantly either with electrostatically cleaned gas or dirty gas.

As indicated above, the electrostatic plant itself is divided into 16 cleaning units, each with two discharge grids placed in series. This multiplicity of chambers was adopted, as already stated, to ensure maximum contact between the electrostatic discharge and the gas to be cleaned, by splitting up the gas flow into multiple streams; also to avoid passing large quantities of dirty gas into the system when cleaning the chambers (during which operation the discharge must be cut off), which would have been the case if a smaller number of larger chambers had been employed. The same remarks apply to chambers off for electrical repair or alteration.

The 32 transformer sets are placed in a building immediately above the cleaning chambers, so as to shorten the lead of high tension cable conveying the uni-directional current to the discharge grids in the cleaning chambers, thereby reducing the amount of electrical leakage to a minimum. By this disposition of electrical plant the current consumption has been kept down to 50 kilowatts for treating the entire make of gas from 3,000 tons pig iron per week.

Each cleaning chamber is provided with two cleaning hoppers, situated under their respective discharge grids. Each grid is provided with rapper gear, operated by levers, which during the cleaning operations shakes the discharge plates and precipitates the dust into the hoppers, whence it is removed by scraper conveyors to the potash extraction plant. The operation of cleaning each chamber takes place every eight hours, for which purpose the gas and current are cut off, the discharge plates rapped, and the dust withdrawn from the hoppers to the conveyors.

The potash extraction plant, which is described fully in a further section of this paper by Mr. Olle Ollander, chemical works manager, and Mr. Frank Bainbridge, chief chemist, consists of mixers for lixivating the soluble salts from the dust (chlorides of potassium, sodium, calcium), revolving filters for separating the insoluble matter from the solution of

chlorides (designed by Mr. Ollander), and two Kestner evaporators.

- a. Removing by fractional crystallization the potassium and sodium chlorides from the calcium chloride.
- b. Separating by fractional crystallization the potassium and sodium chlorides.

The erection of the plant was commenced during the latter period of the war, when constructional steel was practically unobtainable. On this account the authors were forced to construct the gas chambers, gas mains, transformer and potash buildings of ferro-concrete. In the beginning they had doubts as to the ability of ferro-concrete to stand temperatures up to 250 degrees C.; but having submitted slabs of ferro-concrete of the composition it was proposed to employ to similar temperatures over considerable periods of time without ill effect, it was decided to adopt this material in the construction throughout. The authors are gratified to state that the work has withstood these temperatures without leakage and with a minimum of cracking. They would not now hesitate to employ ferro-concrete for similar work at temperatures ranging to 300 degrees C. The design of the ferro-concrete construction was in the hands of the Simon-Carves Company, of Manchester, and the authors have especially to thank J. H. Brown, Joint Managing Director, and John Elcoate, of Middlesbrough, for the excellence of their work and the manner in which their contract was fulfilled.

At the time the plant was projected it was almost impossible to obtain plates, and it was decided to use ferro-concrete for the structure, a further advantage being that there would be much less radiation than with steel plates. In view of the high temperature in the chambers, rising at times to the neighborhood of 300 degrees C., which would occasion heavy stresses, exceptional care was taken in the design and construction of the ferro-concrete. As an example of this the partition walls between the chambers contain four times as much steel as an ordinary ferro-concrete wall double the thickness. The concrete consisted of one part best cement, 10 per cent of its weight of slaked lime, two parts of sharp sand, and two parts of hard burnt red bricks or old coke-oven brick.

On the start up of the plant the expansion of the building was carefully observed, and during the first day did not exceed more than a quarter of an inch, from the center to each end. (The three structures are locked on the center line, between chambers Nos. 7 and 8) Since then further expansion to the extent of one-eighth of an inch has taken place, and the limit seems to have not been reached.

During the course of the first day several cracks appeared, mainly in the region where the hot dirty gas enters the plant. Since then other cracks have developed, but in every case they are symmetrically disposed, and it was satisfactory to note that during the short shut-down at Whit-week almost the whole of the cracks closed up to such an extent as to be practically invisible. In constructing similar chambers again such cracks could probably be entirely obviated by dividing the steel reinforcement, placing half near the outer surface of the concrete, and the other half near the inner surface. A contributory cause of the cracking is that the sliding shoes are of too stiff a type, and an improvement could readily be made here.

As a matter of precaution tie rods have been placed above the roof of the chambers and between the column tops.

Extraction of Potash From Deposited Flue Dust.

Theoretical Considerations—The soluble constituents of the flue dust obtained from the electrostatic plant at Skinningrove Ironworks are almost entirely in the form of chlorides, only very minute traces of sulphate being present and carbonate and cyanide not at all. The average analysis is as follows:

	Per cent
Soluble potassium chloride.....	20.0*
Soluble sodium chloride	8.0
Soluble calcium chloride	7.0

*More recent analyses of dust taken from the full scale plant show a considerably higher percentage of potassium chloride than this.

On this account the separation of pure potassium chloride presented few difficulties.

The method of separation finally decided upon is divided into two stages:

1. Separation of the sodium and potassium chloride from the calcium chloride as a mixed salt.
2. Separation of the potassium chloride from the sodium chloride.

The first stage is accomplished by direct evaporation, and is rendered possible by reason of the extreme solubility of calcium chloride as compared with the solubility of sodium and potassium chloride, 31.7 kilogrammes of calcium chloride requiring rather less than 49.1 kilogrammes of water for solution. If, therefore, the "strong liquor" be evaporated to this concentration and cooled, 90 per cent of the potassium chloride and sodium chloride will be thrown out of solution. It is possible further to reduce the KCl and NaCl content of the liquor, but as the calcium chloride may be used to remove the carbonate from alkali carbonate bearing flue dusts by double decomposition, there is no need to endanger the purity of the mixed crystals by further concentration.

The second separation is based on a series of cooling curves constructed from the data obtained by Precht, Wittgen, Rudorff, and Nichol as follows:

Solubility in Grammes Per 100 Grammes of Water

Degrees C.	KCl	NaCl
0	11.2	30.0
25	15.8	29.0
50	22.0	27.7
70	27.3	26.8
80	30.0	26.4
100	34.7	25.8

from which it will be seen that the solubility of potassium chloride increases with the temperature while the solubility of the sodium chloride decreases. The saturation points from 0 degree C. to 100 degrees C. are shown in the equilibrium curves diagram (Fig. 3).

In this diagram the weight of NaCl in the solution per 100 parts of water is measured along the vertical axis, and that of KCl along the horizontal axis. The points D1, D2, D3, D4, and D5 represent the composition of solutions saturated with NaCl at 0, 25, 50, 75, and 100 degrees C. respectively; the points C1, C2, C3, C4, and C5 that of solutions saturated with KCl; and the points H1, H2, H3, H4, and H5 that of solutions saturated with both salts. The lines D1 to H1, etc., represent the composition of solutions saturated with KCl which contain varying amounts of NaCl. It is assumed that all these lines are straight, and although no actual measurements have been made it is probable that they are curves which differ but slightly from straight lines.*

An extraction of skinningrove flue dust is shown by the chain line. On evaporating this solution no crys-

tals are deposited until a density of 46 degrees Twaddel is obtained. This is shown when the solution is saturated with potassium chloride. If evaporation be now continued potassium chloride crystallizes out until the density of 49.5 degrees Twaddel is obtained, the composition of the solution changing as shown in the diagram by the line joining the point of intersection with H5, at which point the solution is saturated with both salts, and if the evaporation were continued a mixed salt would be thrown out. At this point, however, the solution is cooled and potassium chloride crystallizes out according to the horizontal line H5 G, which, it will be seen, cuts all the saturated lines at points which show a saturation for potassium chloride but not for sodium chloride, finally reaching the point G on the 250 degree C. line, which is the lowest temperature in actual practice. On reheating the solution no crystals are obtained until the point q is reached, at which point the solution is saturated with sodium chloride but not with potassium chloride. Evaporating further, sodium chloride will be deposited according to the line q H5, and if the solution be filtered to remove the sodium chloride, potassium chloride again crystallizes out on cooling, the operations now becoming a cycle, in which, whenever the points G, q, or H5 respectively are reached, the composition of the solution is the same as at the same point in the preceding cycle, the bulk only being reduced.

Extraction of Potash From Deposited Flue Dust.

The dry dust from the conveyor is lixiviated with water or wash liquid as it falls from the conveyor chute into the concrete slurry tanks below the electrostatic plant. In order to prevent any settling this slurry is circulated continuously through the chute, thus producing an intimate mixture, only enough water or liquor being added to produce a slurry thin enough to be pumped through the circulating system and to the mixers. In the mixers, which are steel vessels of about 800 gallons capacity and provided with efficient stirring arrangements, the slurry is boiled and then continuously run down on to a series of revolving vacuum filter drums 1, 2, 3, and 4, situated below the mixer.

The filter drums, which are 3 feet 6 inches diameter and 7 feet 6 inches long, are built of oak laths 3 inches apart, covered with a strong wire net, which carries the filter cloth. To protect the cloth a $\frac{1}{8}$ -inch steel wire is spirally wound round the drums, which are driven by a worm gear and revolve at two revolutions per minute. The wells in which the drums revolve are built in concrete with a cast iron front, and in order to prevent any settling they are made V-shaped, with a stirrer revolving along the bottom. The dried cake containing about 30 per cent moisture is cut off by a steel knife placed in such a position that the cake flaked off from one drum falls into the well of the next, where it is each time boiled with a weaker

liquor. By having four drums four consecutive washings with liquor of falling strength are obtained, the last washing being done with water; and the last cake, free from soluble salts, is transferred by a worm conveyor to railway trucks outside the building, whence it is returned to the blast furnaces. The liquors from the four drums are drawn off by vacuum into separate suction tanks and from there delivered intermittently to the respective storage tanks. The strongest liquor, of about 32 degrees Twaddel, from No. 1 drum is filtered through a sand filter and then delivered to the preliminary evaporator. The liquor from No. 2 drum goes to the slurry tanks, the liquor from No. 3 drum is used for washing in No. 2, and from No. 4 drum for washing in No. 3, and No. 4 receives water.

Evaporation and Crystallization Containing KCl, NaCl, and CaCl.

The strong liquor of about 32 degrees Twaddel is transferred to the feed tank for the preliminary evaporator, where it is heated by indirect steam and then continuously fed into a Kestner Salting type evaporator, in which the separation of the sodium and potassium chloride from the calcium chloride takes place. The crystallization starts at about 62 degrees Twaddel and continues to about 94 degrees Twaddel, and the salt is periodically drawn off on to a vacuum filter, where it is washed once with liquor from No. 2 evaporator in order to free it from any mother liquor containing calcium chloride. When the saturation point of the three salts is reached, which occurs at about 94 degrees Twaddel, the evaporator is emptied and the cycle started again. The residual liquor is evaporated to dryness in open pans heated by breeze fire.

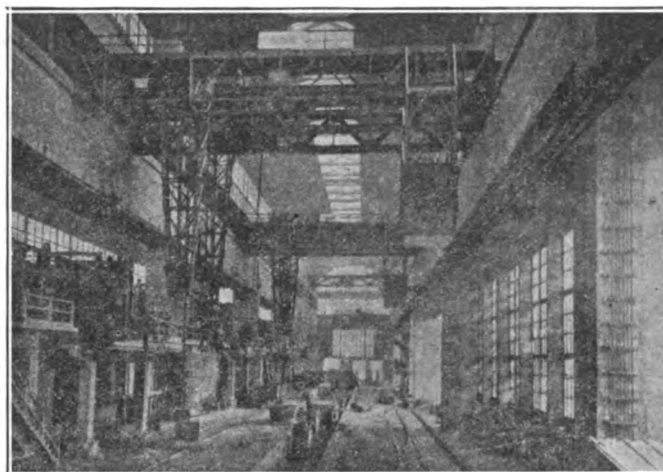
Preparation of Potassium Chloride From Mixed Salt.

The mixed crystals are dissolved in hot distilled water or liquor from the final evaporator in tank from which they pass through a filter and then into the feed tank and finally into the evaporator. Evaporation is then commenced and continued until the liquor has a density of 49 degrees Twaddel. During this evaporation potassium chloride crystallizes out and more liquor is added until the evaporator is completely full of liquor of the required density, at which point the whole contents of the evaporator are run out and passed through a revolving crystallizer, more potassium chloride being deposited during the cooling. The mother liquor is drained from the crystals in a centrifugal hydro-extractor and returned to the feed tank, from which it can either be supplied to the crystal dissolver H or to the evaporator for further evaporation. In the latter case the liquor is evaporated until the density again reaches 49 degrees Twaddel, but owing to the saturation of the liquor only sodium chloride is thrown out of solution during this second evaporation, as explained in the theory of the process. The sodium chloride is removed from the evaporator by means of the vacuum filter box, and the clear liquor run through the crystallizer, when potassium chloride again crystallizes out. From this point the process is cyclic, sodium chloride crystallizing out on evaporation and potassium chloride on cooling. It is obvious, of course, that the above operations may be varied, and modifications are made from time to time in order that the final evaporator may be kept full of concentrated liquor.

*See Blasdale, Journal of Industry and Engineering Chemistry.

Note—Abstract from paper presented at the British Iron and Steel Institute.

Steel Works Department



The Basic Open Hearth Process
By F. L. TOY

The Basic Open Hearth Melting Shop Equipment and
Practice in England.
By GEORGE A. V. RUSSELL

Development of the Steel Industry During the War
in Germany.
By HUBERT HERMANNS

Open Hearth Cause and Effect
By N. E. MAC CALLUM

Gases Obtained in Molten Steel
By HENRY D. HIBBARD

Electric Furnaces in 1920
By A. G. AHRENS

Refractories and Their Relation to Furnaces

The Basic Open Hearth Process

Development and Present Status of Various Fuels—Efficiency of the Various Parts and Their Uses—Slag Analyses and Weight Pouring Temperatures and Alloy Additions.

By F. L. TOY,

Supt. Open Hearth Dept., Homestead Works of Carnegie Steel Company.

PART I.

THE basic open hearth process has been such an extremely important factor in the development of our great steel industry and has contributed so largely to our economic welfare, that it is indeed difficult to outline briefly all its great advantages. It has made available to us the great natural resources of iron ore and produces economically and at a low relative cost, a wide range of commercial steels suitable for practically every application for which steel is used.

The extreme flexibility possible through the various methods devised for its application as a process allows for the production of steels from a great variety of charges and by many variations in method of manipulation, so as to make possible the working of the process economically with regard to the supply of

development of this basic open hearth process cannot be adequately covered or satisfactorily expressed in a paper of the size here given, I will endeavor briefly to trace the development of the process, state some necessary lines of improvement as to efficiency, give some reasons for the present variations in the application of the process to steel making, and touch a little on the present "trend of the times" in regulating charge and method to the ends sought. I hope this small contribution may assist to open up by wider discussions in much greater detail, many of the phases so extremely important in this process, and in greater part deserving of treatment singly in a paper.

Historical.

The experiments of William and Frederick Siemens in England, 1857 to 1861, developed what was absolutely essential to the success of the open hearth furnace as an agent in steel making, gasification of the fuel in combination with a new regenerative principle applied to the heating of the gas and air for combustion. In the period 1863-67, William Siemens and the Martin brothers, of Sireuil, France, had developed the pig and scrap method successfully, and by 1868 William Siemens had made successful as a commercial process the pig and ore process. In 1879 the Thomas-Gilchrist or basic process as applied to the Bessemer Converter was demonstrated as a commercial success at Middlesbrough, England, and its application to the Bessemer and open hearth processes spread rapidly, particularly on the continent, to make available the large deposits of high phosphorus ore.

Samuel T. Wellman built the first successful open hearth furnace in this country at the Bay State Iron Works, at South Boston, in 1869. Its capacity was five to six tons and melted of course on an acid bottom.

Mr. Wellman and George W. Goetz, both of the Otis Steel Company at that time, after study of the basic open hearth process in Europe, made steel on a basic bottom at the Otis Steel Company's plant for about four months when the experiment was discontinued. The manufacture of basic open hearth steel as a commercial product dates back from March 28, 1888, when first produced at the Homestead Works of Carnegie, Phipps & Co. Notwithstanding considerable difficulties in operation, mainly due to the dolomite and tar bottom, basic steel was continuously made at this plant with such success that during 1889 the construction of additional basic furnaces of the Lash type was commenced, as an addition to the existing four furnaces, so that by the close of 1890, 16 basic open hearth furnaces were in operation at these works. Their capacities ranged from 15 to 35 tons and all were increased during the next few years

(Continued on page 43)

The strides made in operating practice in the steel industry during the period of the war are unprecedented in the history of steel manufacture. The comparisons between the open hearth practice in England and Germany, where many revolutionary changes were made, are of particular interest in connection with Mr. Toy's recent and very valuable paper on American practice.

scrap and pig iron, and the quality of the same, physically and chemically.

The fact most important in considering its tremendous growth as a process is, it has permitted the use of iron of any phosphorus content, thus making immense deposits of ore which could not otherwise be utilized.

It is almost impossible to estimate the possible state of our steel industry at the present time had the basic process as carried out in the Bessemer converter and particularly in the open hearth furnace not been such tremendous factors. Had their influence been lacking, then it takes no stretch of the imagination to conceive a quite different status as to phosphorus specifications on finished steels as compared to present ones, for reasons both of volume of production and of the phosphorus content.

It should be borne in mind in considering the growth of basic open hearth furnace production and of the total production of open hearth steel, that the basic open hearth process has made possible for the acid open hearth process a far cheaper product and a greater application to quality production by furnishing it a cheap and low phosphorus scrap.

Basic Open Hearth Process.

Since all application and all phases of the modern

From a paper presented at the fall meeting of the American Iron and Steel Institute in New York, October 28.

The Basic Open Hearth Melting Shop Equipment and Practice in England

A General Review of the Mixer Plant and Practice—Melting
Furnaces—Metallurgical Practice—Handling of Materials and
Products—Layout of the Plant.

By GEORGE A. V. RUSSELL.
Assistant Works Manager—Sheffield, England.

THE production of structural steel by the basic open-hearth process has increased considerably of late years in almost every steel making country and this development is still proceeding. In our own land the basic process has made enormous strides since the beginning of the war and now occupies the premier position as regards output. Table 1 gives the output of steel by processes in Great Britain during the year 1918, and will enable the lead obtained by the basic process to be appreciated. In Table 2 are given particulars of the extensions to steel works authorized by the Ministry of Munitions between the years 1916 and 1918, and it will be noted that basic open-hearth furnaces largely predominate in these new plants. In the United States also, the pride of place falls to the basic open-hearth process. In France, Germany and Belgium the Thomas converter is still responsible for the bulk of the output,

but the open-hearth process is gradually and surely winning a more and more important position in the industry of these countries.

In view of these facts it was thought that a short account of the plant and methods in use in modern steel works for the production of liquid steel by the basic open-hearth process might be of some interest. It was the author's original intention to extend this review to ingot casting practice but more mature consideration showed him the field was already wide enough for a single paper and hence this very important and interesting subject will only be touched upon is so far as it affects the layout of certain portions of the melting shop. In the same way gas producer practice will only be briefly dealt with and many aspects of this subject will be left unconsidered as the author hopes to deal with the general fuel sup-

(Continued on page 38)

Development of the Steel Industry During the War in Germany

A General Review Showing the Various Improvements That
Have Been Made in the Different Stages of Steel Manufacture in
Germany During the Past Four Years.

By HUBERT HERMANN.
Special Correspondent, Blast Furnace and Steel Plant

PART I.

THE increase in wages as well as the decrease in available labor required an extended use of efficient ore handling machinery. Mainly the large plants, situated on the Rhine or its tributaries, have been supplied with installations of this kind, some of which can be considered as models in regard to efficiency and technical design.

As a rule, ore crushers are built as stationary installations, which are fed by means of suitable conveyors or elevators. With such an arrangement, however, is connected a considerable loss on account of the waste trips to be made. The ore bridge avoids these disadvantages, as the crusher forms an integral part of the bridge, thus producing large savings of current, operation and maintenance.

The bridge also deserves special interest on account of its size. The structure consists of the bridge proper and of a jib crane, traveling on the top girder of the ore bridge. The latter conveys the ores from the ship either directly to the crusher or to a tempo-

rary storage pile. The main dimensions of the installation are:

Ore Bridge.		
	Feet	Inches
Total length of travel	181	10
Span	95	10
Free length over water	47	8
Free length over land.....	38	4
Distance between top of yard rail and bottom of bridge	43	4
Distance between top of yard rail and top of bridge	60	0
Gauge	40	0
Bucket Jib Crane.		
Reach of boom	35	0
Capacity	15	gross tons
Gauge	15	0
Distance between center line of wheels....	20	8
Distance between top of rail and rope sheave	34	2
Total distance between center line of support on water side and rope	70	0

The operating velocities of the installation are considerable. The bridge travels with a velocity of ap-

proximately 100 feet per minute, the crane with about 535 feet per minute, the lifting velocity of the crane is 200 feet per minute and its turning velocity 480 feet per minute, the latter being measured on the hook.

The ore crusher is mounted on a separate carriage, which is traveling back and forth with the bridge and which crushes the ore to about head-size. The crushed ore falls into a bin, located below the crusher, which has two chutes with grates, by means of which automatic unloaders are filled. The total power required amounts to 660 hp.

For charging the furnaces in England and America tilting buckets are still in use, whereas in Germany this type has been mostly discarded in favor of the cylindrical bucket with bottom discharge in the shape of a furnace bell. The main disadvantage of the tilting buggies is due to the fact, that, when tilting, the charge will be separated according to its specific weight, thus causing an uneven distribution of the material and, in turn, irregular working of the furnace. The cylindrical bucket, on the other hand, serves as a hopper for the top, preventing an unnecessary dumping and damaging of the charge. To prevent the escaping of furnace gases during charging, a cover is suspended from the trolley which carries the bucket, in such a way, that it is lowered automatically, before the contents of the bucket are discharged into the furnace, thus closing the top gas-tight. After the empty bucket is lifted from the top of the furnace, the cover is lifted automatically from the bucket, thus allowing the gases in the bucket to escape. Fig. 1 shows the installation of the skip-hoists at the Gute Hoffnungs-Huette.

A modern arrangement for the automatic lowering and lifting of the cover is shown in Fig. 2. The cover b, freely sliding on shaft a, is held up by a double

hook c. This double hook is connected to a rope f, which is carried over rollers d and e, holding on its free end a counter weight g. The motion is limited by stops h and i, which correspond to the highest and lowest position of the cover b. By hitting against a stop l, which is fastened to the track on the hoist, hook c is thrown back, thus allowing the cover to drop down and close bucket. When the bucket is lifted from the top of the furnace and starts on its downward trip, the now free hook c grabs under trunion n and keeps cover b lifted again.

The furnace proper has not been changed except in a few minor details.

The air for the blast furnaces is more and more supplied by turbo-blowers, on account of the saving in space, connected with their installation. A comparison of the floor space required by a reciprocating blowing engine and by a turbo-blower shows the first one furnishes about 31,800 cubic feet of air per minute with a pressure of about $5\frac{3}{4}$ pounds per square inch, whereas the latter delivers about 42,700 cubic feet per minute with a pressure of approximately $6\frac{1}{4}$ pounds per square inch. The blowers are, in most cases, not water cooled. They are either steam driven by means of high pressure, low pressure or mixed pressure turbines or they are electrically driven, which, in some cases, may be of more advantage. The blowers consist of one cylinder, within which shaft and wheels revolve. The cylinder is partitioned horizontally, division walls and diffusers being cast with the cylinder.

The design of the gas blowing engine has not been improved. They are mostly built as 4-cycle tandem engines. The main point to be kept in view, is an easy accessibility of all parts, a quiet running of the valves and a quick and sensitive regulation. The use

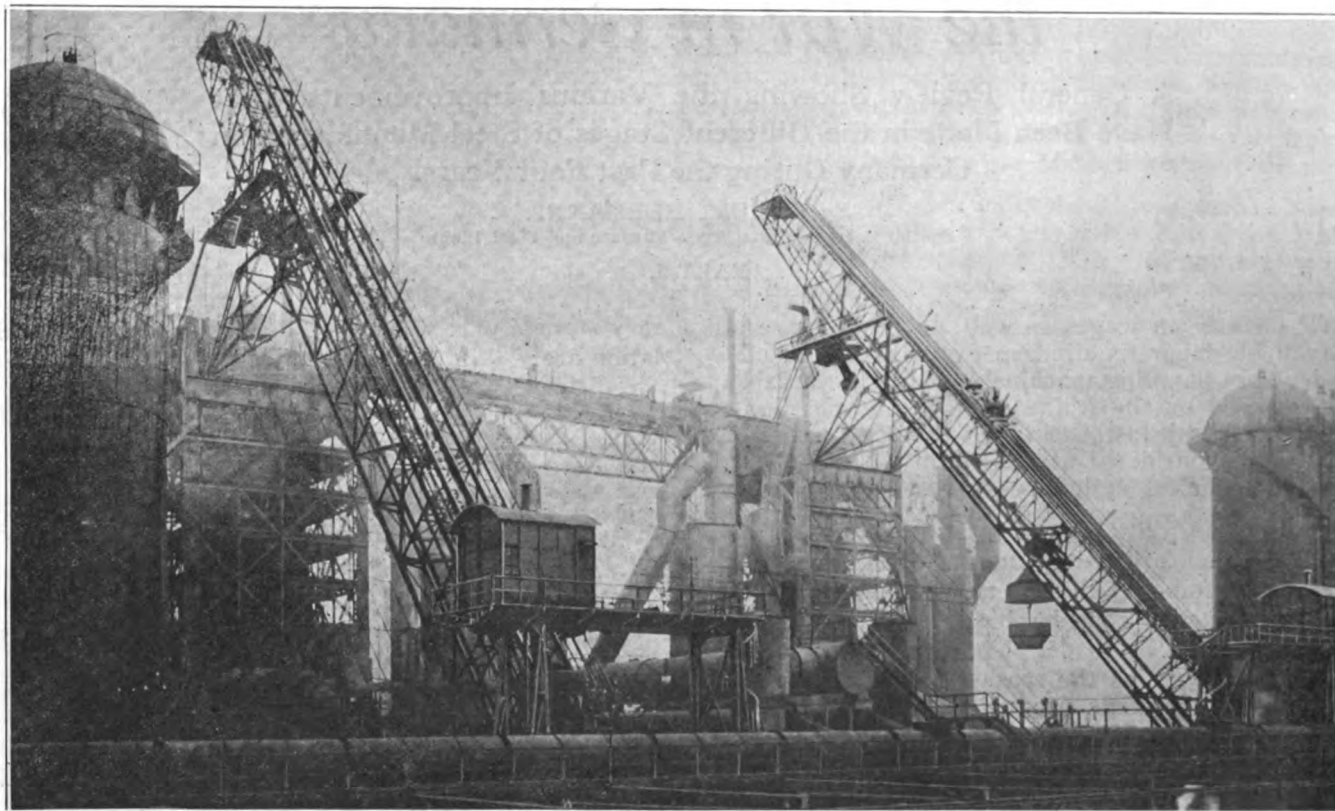


Fig. 1.

of mixing valves of special design prevents, even with tar and dust-laden gases, a premature coating and clogging up. Cylinders, pistons, piston rods and exhaust valves are all water cooled.

Although the internal combustion engines are highly superior to steam engines as far as thermal efficiency is concerned (35 per cent against a possible maximum of 17 per cent), a large quantity of heat is lost with the exhaust gases and the cooling water. For the reclamation of this heat, installations have recently been built which are similar to those used for utilizing exhaust steam. Fig. 3 illustrates two waste heat boilers with superheater and feed water heater, which are connected to two gas engines of 2350 hp each. The steam pressure is about 155 pounds per square inch with about 350 degrees F. superheat.

The construction and arrangement of these waste heat appliances are, in general, very variable. They may be designed as vertical or as horizontal boilers,

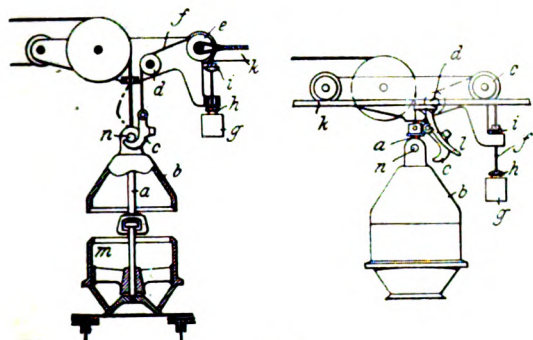


Fig. 2.

as a system of tubes or as chambers of different form and size, all to suit conditions. For high steam pressures in connection with superheaters and feed water heaters, boilers are mostly used. The working of a waste heat installation should not be considered according to the size of its heating surface, but according to the obtained heat utilization per hp of the engine, because the efficiency of such an installation depends only on the operation of the engine.

The cleaning of the blast furnace gases has been perfected by a process described. The apparatus consists of a combined cooler and washer, a fan and a separator. In Fig. 4 the cooler and washer is shown,

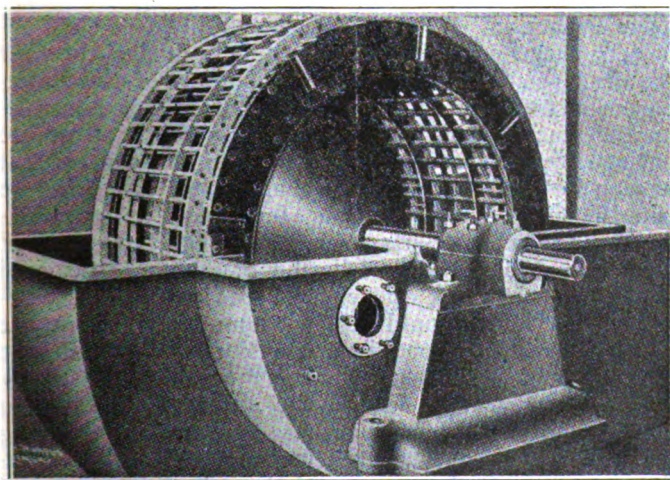


Fig. 4.

the top of the housing being removed. The gas is cleaned in the following manner:

After entering through the top of the cooler, it travels towards the center of the washer, in a direction opposite to that of the cooling water, which enters from the side, and also opposite to the centrifugal force. In the center, the gas, under the influence of the centrifugal force, is mixed with the water spray, cooled and freed of its dust particles. As the gas passes through the combined cooler and washer in a direction opposite to the flow of the water, it always strikes a purer and cooler spray of water and is thus itself cleaned and cooled. The fan forces the gas into the separator where it is liberated from its contents of moisture. By this method the gas is cleaned and cooled at the same time, thus obtaining, behind the apparatus, a clean, cool and, therefore, dry gas and eliminating any possibility for a deposit of slush in the lines. The cooling of the gas to as low a temperature as possible is an essential factor for the heat utilization because the lower the gas temperature, the

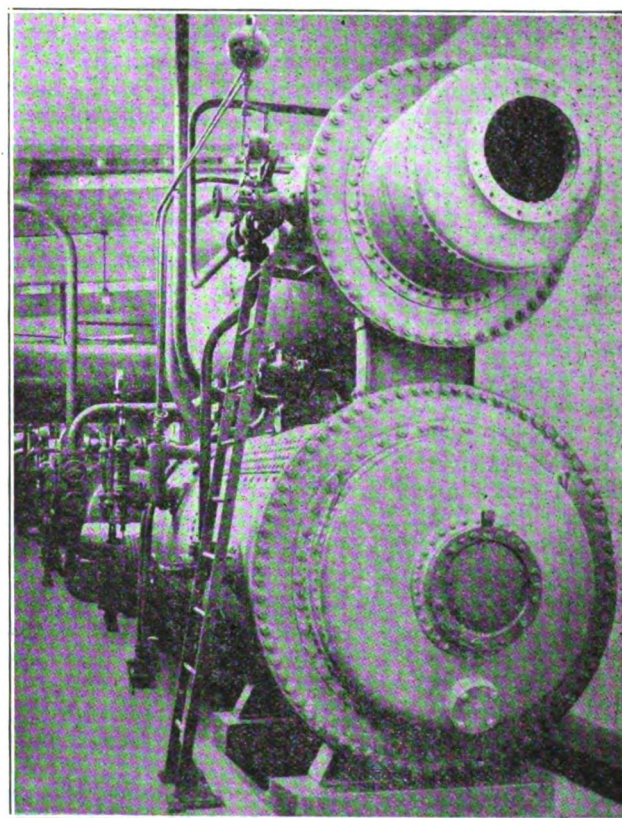


Fig. 3.

higher will be the heat efficiency of the gas on account of its smaller contents of moisture.

An improvement of the ladle cars and ladles has been effected. The distance between blast furnaces, mixers and steel plants is, generally, long and results in an undesirable cooling of the surface of the molten iron on account of the large open area. This, in turn, causes a severe loss in heat and a freezing over of the slags on top of the iron. To prevent this disadvantage, the ladles have been closed with a hood, which has openings for filling and emptying the liquid iron. A ladle of this type holds 15 tons of liquid iron and has a hood with a funnel-shaped opening in the center

for filling and one nozzle on each side for emptying either way.

A ladle and car can always be used for filling converters, because the opening of the ladle and the opening of the converter can always be kept in the same relation to each other by a corresponding lowering of the two. Conditions, however, are different with open hearth furnaces. As the inlet to the furnace is stationary, provisions must be made on the ladle car to insure a smooth running of the liquid metal into the furnace. This is done in such a way, that up to a certain point, the outlet of the ladle is lowered, but from there on it is kept stationary and the whole ladle is lifted and swung around the end of the outlet. Needless to say, that this arrangement is not required where ladle cranes are used.

Fig. 5 shows a sketch of the working mechanism for a simultaneous lifting and tilting of the ladle. The chain-wheel *a* is rigidly connected to the trunion of the ladle. Around this wheel runs a chain, one end of which leads over a roller *b* to a cross piece *c*, and

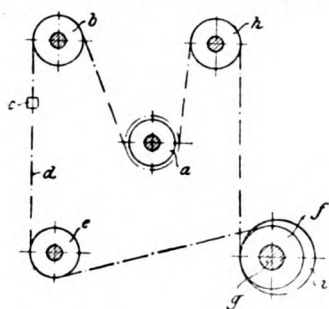


Fig. 5.

from there in two lines over two rollers *e* to roller *f*, which are centrally fixed on the driving shaft *g*. The other end of the chain leads over roller *h* to roller *i*, fixed eccentrically on the driving shaft *g*. When shaft *g* is revolved, the end of the chain connected to rollers *f* and *i* move first in such a manner, that the ladle is tilted, until after a certain part of the revolution is completed, the excentric part of roller *i* comes into play, causing a quicker rolling up of the end of the chain *d* upon *i*, then the whole chain can be unrolled. The ladle will now not only be tilted but will also be lifted, because it is moved in slots, which prevent its falling out.

Before the war, many German blast furnace plants had installations which were supposed to reduce the cost of loading and of transporting the pig iron. Generally, special cranes with large magnets were used for this purpose, which could take up whole strings of the pig and bring them to the pig breaker. Some of these cranes had, also before the war, been fitted with breakers, which enabled the strings of pig-iron to be broken up right in the cast house.

The design of satisfactorily working engines for driving the pig breakers was difficult, because, for obtaining efficient operation, a large number of blows had to be taken into consideration; the grade of the casting bed had also to be taken care of by regulating the position of the hammer to suit the floor elevation. According to the relative location of the casting beds to the blast furnaces, either the motion in longitudinal or that in transverse direction had to be effected with two different velocities, a slow one for the breaker work and a quick one for loading the pig by means of the magnets.

The fundamental principle of the working of a breaker crane is as follows: A belt carrying a ram, moves up and down in a shaft, on the top of which is located a belt pulley with side flanges. The belt touches the pulley for about three quarters of its circumference. A pressure roller forces the belt against the pulley in such a way, that there is enough friction between belt and pulley to lift the ram. After reaching a certain height, the pressure roller is lifted and the ram falls down with a certain velocity. Pressure and lifting of the pressure roller is done automatically. The load on the driving motor is, of course, variable. In order to prevent the heavy masses when lifting the ram, from damaging the motor and in order to be able to design the motor for average load, a fly wheel is attached to the motor shaft, which, during the falling

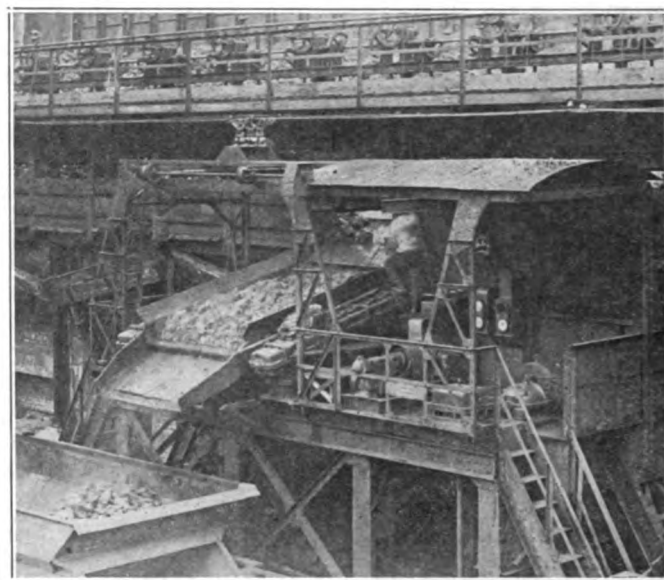


Fig. 6.

period, absorbs the excess energy and supports the motor when the ram is lifted. The pig iron proper is, by means of magnets loaded into wagons and taken to the pig dump. The shaft for the breaker is suspended from a separate winding machinery and its height can be regulated to suit the level of the casting bed. As long as the crane is used for loading the pig iron, the shaft can be taken up altogether and is kept out of the way until the loading is finished.

Coke Plants.

The large demand for by-products during the war required the largest possible utilization of the existing coke oven plants; it was, however, not possible, on account of difficulties, prevailing at the time, to enlarge or increase those plants. On the contrary, it had to be tried to reduce the operating force and to run the coke ovens with as few men as possible. Among the main points, which had been looked after, were the slopes, the installation of which has caused a reduction in work and cost of loading the coke, because that latter could slide automatically down the inclined grate and could then easily be changed into railroad cars or ships, by simply opening the gates. A further advantage lies in the possibility of storing large quantities of coke on the slope, thus enabling for sometime uninterrupted loading, even if a breakdown occurs on the ovens. If there is a deficiency of cars, the arrangement can be changed quickly, allowing

the coke to be taken to the storage pile instead of to the screens. Another advantage is due to the fact, that the working men are not so much subjected to water when cooling the hot coke.

The gates, mentioned before, have recently been designed in the form of double gates, which need only a small amount of power for operation and which have given satisfactory results.

The gate consists of two slides which work in opposite directions. The lower, angle shaped part forms, when open, the elongation of the slope and retards or stops the motion of the moving coke quickly. The flat gate above is moved downward when closing and is supposed to prevent any damage done by coke pieces falling through the openings of the slope.

An arrangement of this kind is shown in Fig. 6 which illustrates the application of the double gate with a traveling screen. The coke, falling through the gates on the sieves, is separated into fine and coarse material. The coarse coke runs through troughs into railroad cars or charging buckets, whereas the fine material is discharged into mine cars. On the lower end of the slopes a grate is provided to prevent the wash water entering the gates; from here it is taken to the settling basins.

Mixers.

It is a well known fact that the mixers have found a wide application in Germany. Originally built in a shape like converters, the form was later changed to the present cylindrical shape. Innovations worthy of note, however, have not been made on these cylindrically shaped mixers. The fuel used is blast furnace gas, coke oven gas or producer gas.

Recently a new type of mixer has been introduced into the practice, which are called "shallow bed" mixers. In order to permit a quicker purification of the iron, the mixer is designed in such a way, that the bath has a large area with a corresponding shallow depth, thus offering to the fuel gases a large surface. This type of a mixer is, therefore, in principle as well as in form, similar to an ordinary tilting furnace, as can be seen from Fig. 7, which illustrates a mixer of 300-ton capacity. The body of this mixer rests on two sets of roller bearings, its axis is above the level of the iron and at about the same height as the center line of the posts. This arrangement does not require

a shutting off of the gases whenever the mixer is tilted. The ports are detachable, because they are easier destroyed than the rest of the brick work of the mixer; in this way they may be quickly exchanged against new ones, whenever necessary. The regenerating chambers are partly arranged above the floor, but show, in general, the same design as those for an open hearth furnace. Both ends of the mixer, as well as the ports are water cooled.

This type of mixer is not built for more than 300 tons capacity, because, on account of the shallow depth, the horizontal dimensions would become too large. Besides, larger quantities could not be purified easily and the working of the charge would become difficult. Even for a mixer with 150 tons capacity, the length between ports amounts to between 45 and 50 feet. The machinery for tilting the mixer is driven by electricity.

Recently the "shallow bed" mixer has been introduced into the iron foundries. But it is evident, that its application is only warranted in such foundries, which own blast furnaces, or which are in a position to buy the iron in liquid form. Compared with the cupola-foundries, this operation has the big advantage, that it eliminates the remelting of the pig in the cupola. The iron coming from the mixer is of an excellent quality, and is entirely equivalent to the iron coming from a cupola. Another advantage of the foundry mixer is due to the possibility of a large production with low maintenance cost.

The treatment of the iron in the "shallow bed" mixer is the same as that in a Talbot furnace; iron ore and calcined lime for making acid open hearth steel. The life of a mixer depends upon the temperature obtained and on the kind of fluxes. Such mixers, which are not used for preliminary purification and which seldom have a higher temperature than 2500 degrees F., can be run for about a year without making repairs. In most cases, however, they have to undergo general repairs after a year's run, but even then the roof is left untouched, because it is least exposed to the action of the hot gases. In a mixer of 200 tons capacity and for a total tonnage of 600 tons the operating expenses before the war, amounted to .033 dollars for coal, .010 dollars for wages and .006 for maintenance, all figures per ton.

(to be continued)

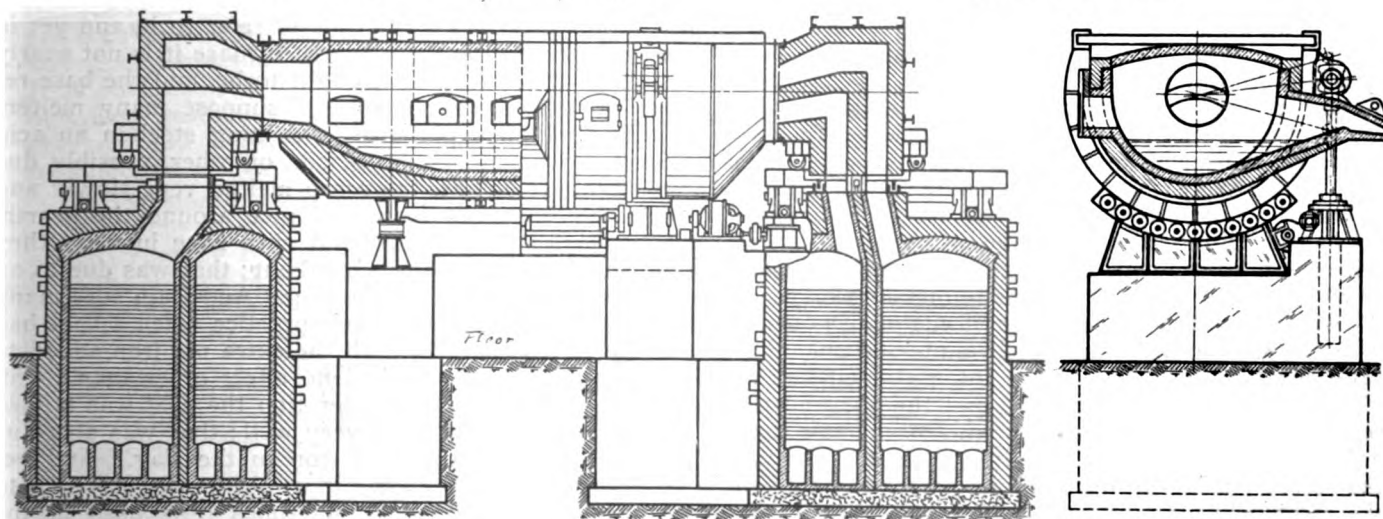


Fig. 7.

Open Hearth Practice Cause and Effect

Discussion on Effect in Open Hearth and the Location of Cause of Such Effect—Suggestions by Which Our Open Hearth Difficulties May Be Remedied.

By N. E. MAC CALLUM,
Superintendent Steel Plant, Phoenix Iron Company.

OVER the entrance to the laboratory of Prof. Kirkaldy, a physicist of two generations ago, were displayed the words "Facts Not Fallacies," and I wish we could apply those words to our knowledge of open hearth practice and construction, but, unfortunately such is not the case and the purpose of this article will be to discuss some effects which are quite familiar and attempt to locate causes which are not so familiar and if successful to look for or suggest a remedy. In spite of the fact that the open hearth furnace is by far the largest producer of steel it is probably beset with more conflicting ideas and theories

In this article, it is pointed out that although melters have been experiencing the same difficulties over a number of years, no standard methods of overcoming these difficulties have been adopted. The author believes that too often when trouble occurs it is blamed to some particular reason, but is not really investigated to find if such is the cause or not. He believes that each variation occurring should be carefully studied.

than any other industrial producer and in this article, which necessarily must be brief, it will only be possible to skim over the surface giving an instance here or there which may help to bring out certain facts or fallacies, as the reader may decide.

On visiting a plant one is often struck with the tenacity with which certain ideas of construction are held, and on visiting another he may find the same tenacity, but different construction, in fact he may visit half a dozen plants and find different construction at each, but, all going complacently along in the belief that each is right. It is, of course, within the pale of possibility that each is right and the construction whether it be roof, ports or some other part of the furnace, has been evolved as best suited to the peculiar conditions which each plant has to meet. It is not at all unlikely that a plant making steel from a mixture of 50 per cent pig iron and 50 per cent scrap will operate differently from one using 20 per cent pig iron and 80 per cent scrap, and that the construction which will yield good results in one case may not work equally well in the other, or, if one plant is using hot metal and another cold, it is quite possible that a different furnace construction for each will be desirable. It must be remembered that the open hearth furnace is adaptable to steel-making from raw materials covering all classes of iron or steel. It can make steel by using all pig iron and no scrap, or it can make steel by using all scrap and no pig iron, or by any of the endless combinations that can be made by varying the proportion of pig iron to scrap. What

any particular plant may use will be determined largely by the relative values of pig iron and scrap, the available market and whether it controls its own sources of pig iron and scrap or must depend on outside supplies. If pig iron is high in price, one plant may curtail its use or discard it entirely, another plant will use a class of scrap that others will avoid, and still another may be fortunate enough to be supplied with pig iron irrespective of market value. Then again some plants use scrap of a miscellaneous assortment of which two cars are hardly alike, and consequently the melting is irregular. So it is obvious that steel is being made under constantly varying conditions, and that these conditions will have more or less to do not only with the increase or decrease of product, but also with the life of the furnace itself. These conditions have been further aggravated during the last few years by the unsatisfactory coal situation, in which time it has been a case of not getting what was wanted, but of accepting what was offered, regardless of analysis or cost. Before considering the effect which these conditions have imposed on steel furnaces, it may be advisable to refer to a few chemical actions that occur during the process of making steel, and that they may be intelligible to those who have had no technical training, chemical nomenclature will be avoided as much as possible and the simple terms of "acid" and "base" will be used. The only acid we shall have to consider is silica, either in the form of sand, brick, or in higher grade clay bricks, in which silica is the chief component. In the bases we shall have to include lime, magnesia, dolomite and one other which is so important it cannot be dispensed with and yet so harmful that it is the greatest source of trouble with which the furnace man has to contend, in fact it is an inanimate Dr. Jekyll and Mr. Hyde. Nature has supplied us with abundant quantities of this dual actor and its use is so common that it may seem a waste of time to refer to it, and yet in its relation to the open hearth furnace it is not nearly as well understood as it ought to be, and the base referred to is oxide of iron. I suppose many melters will recall an experience in making steel in an acid furnace when for some reason or other, possibly due to shortage of gas, the scrap melted very slowly and the slag began to foam and race around the hearth, scouring out the banks, and with hose in hand they anxiously watched for a breakout; that was due to an excess of iron oxide in the slag. And I am sure many will recall instances in basic practice when a heat had melted "dead soft" and all the extra pig iron added to give carbon and heat had no effect other than to fill up the hearth, and in desperation the heat was tapped and the steel didn't roll very well; that was also due to an excess of oxide of iron in the slag. And yet every furnaceman knows it would not be possible to get along without it. Sometimes it is used in the form of iron ore, sometimes it is used as scale and sometimes as cinder from the heating furnaces, but,

no matter in what form it is used, its function is to supply oxygen to the bath. Now, oxide of iron as the layman knows, is composed of iron and oxygen, and each has a great attraction for the other. After being forced apart by metallurgical processes we eventually have steel, and its one aim seems to be to get that oxygen back again. If allowed to lie in a moist atmosphere it soon turns to rust (oxide of iron). If heated to redness, scale (oxide of iron) forms and if brushed off immediately forms again, and the higher it is heated in the presence of oxygen (air) the more quickly will it seize oxygen and return to its natural state. Oxide of iron is not always the same, it exists in several varieties, having different proportions of iron and oxygen, but the one that is of most interest to the steel maker is known as ferric oxide which in this article will be called oxide of iron unless otherwise stated. Before going further, however, the action of acids and bases should be clearly understood. All open hearth men know that the difference between an acid furnace and a basic furnace is that the hearth of the former is composed of sand and the hearth of the latter of magnesite or dolomite, and they also know that if the slag from an acid furnace were poured into the hearth of a basic furnace or vice versa that the hearth would be destroyed. Now, that in a general way, illustrates the destructive action that occurs between acids and bases at high temperatures. Melted silica will attack lime or magnesia and a base or basic slag will attack silica.

Of the bases mentioned, lime, magnesia, dolomite and oxide of iron, the activities of the latter are not confined to either acid or basic slag, indeed with the exceptions already noted, its influence in the slag will rarely give any concern. It, however, exists in another form which is very destructive, causes expensive delays and is difficult to cope with, but space will only permit of considering its effects on the checker work of the regenerator chambers.

Some years ago an idea prevailed among furnace designers that the capacity of the regenerators or more correctly the space occupied by the checker work should be 100 cubic feet on each end of the furnace for each ton capacity of the hearth. Just how these figures were reached is not clear and it really does not matter in view of the changes that have taken place since then; suffice it to say that in some economical furnaces the total checker space on each end of the furnace is only 16 cubic feet; 10 cubic feet for the air and 6 cubic feet for the gas per ton of hearth capacity, and it is more than likely some furnaces have less. It is obvious that if the chambers are too large the outgoing gases will not be sufficient to heat the checkers and if too small that the checkers will not be sufficient to heat the incoming air.

A few months ago a copyrighted article appeared in a leading steel trade journal on this subject and stated "running the gas through the air checkers has been the subject of a patent, the idea being based upon the reducing action of the gas, but this deposit contains very little iron ore when there are adequate cinder pockets." The writer then quotes the composition of the deposit as found in a foreign furnace and refers to the deposit as a dust that collects on the upper portion of the checker work.

There are various names for this deposit. The workmen on the furnaces often call it soot. When a furnace begins to work badly they say "the checkers are full of soot." A book I have at hand, refers to it

as the "carbon coating", and so far as the effect goes, one name is as good as another, but the intelligent furnaceman knows that the major portion of that deposit is oxide of iron and no matter how adequate the slag pockets are they will not prevent this oxide from depositing in the checker work.

This clogging up is of course a serious matter and much thought has been expended in devising ways and means which would increase the life of the checkers by preventing the passages from blocking up. Checker bricks of various designs have been used, and almost every conceivable method of laying ordinary brick has been tried, some with straight vertical flues, some with vertical and horizontal flues, some with staggered flues, some with larger flues at the top than at the bottom, and pockets have been constructed in the upper courses for the purpose of collecting the dust before it reaches the checker work.

A little thought will show there is no mystery about this so-called "dust"; it certainly must come from some source and the only possible way in which "dust" (mechanical matter floating around) could reach the chambers would be during the making up of the hearth and only then if the repair material were shoveled in dry, or if lime were added to make the slag more basic, it is probable a little dust would reach the checker and last but not likely some ash from producers under high steam pressure might be carried to the chambers. During the melting of the charge small particles of oxide of iron are constantly being emitted, and during the working of the heat a violent ebullition will throw off sparks of iron oxide, but probably most of these sparks are checked by impinging against the ports and bulkheads, and some without doubt reach the checker work, but the greater part of this "dust" is caused by oxide of iron flowing through the checkers in the form of vapor. When galvanized scrap is charged into an open hearth furnace it is a familiar sight to see the fumes of oxide of zinc coating the furnace a bluish white and rolling out of the stack in clouds. The galvanizing has been vaporized and converted into oxide of zinc, and there is every reason to believe the same thing occurs when iron or steel scrap is melting down. The vaporizing will, of course, occur at a much higher temperature, and in much less volume than in the case of the zinc. As an evidence of this vaporization we might refer to the checkers of a steel heating furnace where this same oxide of iron deposit is found and as it certainly cannot be caused by ebullition it is difficult to account for its presence there unless carried over as a vapor.

Now let us consider how this oxide affects the air chambers. It is general practice to build both ends of a furnace as nearly alike as possible, that is the ports, uptakes and checkers, and yet it occasionally happens that one air chamber may run much hotter than the other. We can test the flues with an air gauge and we can measure the air as it is drawn into the air valve and find the results on both ends practically the same, and there is nothing to indicate why the chambers do not attain the same temperature. It can be corrected to some extent by irregular reversing, but the only explanation to account for this irregularity seems to be the difficulty of controlling hot currents and it is possible that the gas outlet one end is getting more than its share of the outgoing waste gases. I merely mention this as incidental to the point I want to bring out, namely, that the cold chamber will clog up much more quickly than the hot one, and if we examine the "dust" in the cold chamber

we will find it consists of a dark brown amorphous mass, filling up the interstices of the checker work. It is porous, loosely held together, and can be crushed easily in the hand, it varies in composition but consists mainly of iron oxide (probably higher than ferric), small quantities of silica, manganese, lime, magnesia and sulphur. In the hot air chamber we will find this same deposit, but only in the cooler parts of the chamber, in the hotter parts it will be found to have fused with the checker brick, just as we should expect in remembering the action of bases and acids at high temperatures.

Now, what happens in the gas chambers? It is certain that the outgoing gases that pass through the gas chamber are precisely the same as those that pass through the air chamber, so why should the gas checkers not clog up the same as the air checkers? In the first place it must be remembered that the incoming gas enters the chamber at a temperature of 1,000-1,200 degrees F., while the air enters at atmospheric temperature, so that if the outgoing gases should raise the air checkers to 1,500 degrees, the gas checkers should be raised to 2,500-2,700 degrees.

In the second place the producer gas entering the chamber contains powerful reducing agents, carbon monoxide, hydrogen and methane. Now a reducing agent is just the opposite of an oxidizing agent, it has a greater affinity for oxygen than the substance with which the oxygen is combined, and in the case of iron oxide it has the power to take the oxygen away from the iron. For example, if steel is heated in a glass tube through which oxygen is passing, it will be converted into oxide of iron, and conversely, if oxide of iron is heated in a glass tube and a reducing agent such as carbon monoxide, hydrogen or methane (natural gas) passed through the tube, part of the oxygen will be taken and if we continue the operation a little longer, all of the oxygen will be taken away and metallic iron remains. And these are precisely the conditions that prevail in the gas chamber. As the outgoing gases for 15 or 20 minutes pass through the checkers they leave a thin deposit of iron oxide; the furnace is then reversed and for the next 15 or 20 minutes producer gas (containing reducing agents) fills the chamber, and it would seem an absolute certainty that the iron oxide if not reduced to metallic iron is at least converted into a lower oxide. It seems probable, however, that part at least is reduced to metallic iron and at the high prevailing temperature may again be vaporized and return to the furnace. This seems to be borne out by the fact that the gas checkers do not wear away to any extent, nor do the interstices fill up with fused brick as they do in a hot air chamber. A practical demonstration of the action that takes place in the gas chamber is easily carried out by piling some of the deposit (previously described as being found in the cold air chamber) on a brick and placing it on the top course of checkers in a gas regenerator. After each reverse the pile will grow smaller until at the expiration of 12 to 18 hours it will practically have disappeared.

There is one more point that should be noted, and that is that the deposit does not end in the checkers, it will be found between the walls that carry the tiles to support the checkers, and the paving, walls and roof of the flues that lead from the chambers to the valves and from the valves to the stack will be thickly coated and the deposit will be the same, irrespective of whether flues lead to the air or gas chambers.

This is due to the fact that there is not sufficient temperature for any reducing action to occur but shows that the waste gases are carrying this oxide through both air and gas chambers and that when comparatively cold surfaces are encountered the iron oxide deposits.

As previously stated the condition is a difficult one to cope with, but nevertheless it is not rather a reflection upon open hearth practice that after so many years of operation that at least some definite plan of laying checker brick has not been decided upon? The answer seems to be that we have attributed effects to wrong causes. Sufficient importance has not been laid to the varying conditions under which furnaces are operating and when these conditions are such as to cause the checkers to clog quickly, we are likely to try some new combination of checkers, when the fault lies, not with the checkers, but with the melting conditions. It is evident that if furnaces are operating with poor quality of gas that melting will be slow, and more oxide of iron will be carried to the checkers, and the same is true with the charge, if a high percentage of scrap is being used it will melt slower and produce more oxide of iron and consequently more clogging than if less scrap were used. In other words, the longer the charge is exposed to the flame, the more oxide will be produced, and the life of the checkers will be shortened accordingly. When these conditions obtain there is apparently only one remedy, and that is to change the air checkers more frequently.

When a furnace does not yield the service expected we wonder if this or that is right or wrong, and if some definite plan could be decided upon for checker laying it would do away with one of the most fruitful sources of "wondering". The writer has tried about every known combination and has found nothing more satisfactory than the straight vertical and horizontal flues. The regular $10\frac{1}{2} \times 4\frac{1}{2}$ silica block is used and the vertical openings are $5\frac{1}{2} \times 4$, and the horizontal ones $5\frac{1}{2} \times 4\frac{1}{2}$.

In reference to running the gas through the air checkers it undoubtedly lengthens the life of the checkers, but to resort to that method often enough to keep the air checkers as clean as the gas checkers would hamper the working of the furnace, since the combustion is not as keen as when the gas enters the furnace through its regular channel.

The natural thought that arises from what has been stated suggests the possibility of a furnace, the chambers of which are constructed so that gas and air can be interchanged as often as the furnace is reversed, and that the port construction is such that the combustion will be as keen one way as the other, irrespective of which chamber the gas is passing through, and if this can be accomplished, I believe checker trouble will have been largely eliminated.

THE BASIC OPEN HEARTH MELTING SHOP EQUIPMENT AND PRACTICE IN ENGLAND.

(Continued from page 31)

ply and distribution problem in an iron and steel works in a communication to another body.

The chief cause of the rapid growth of the basic open-hearth process is to be found in its suitability for dealing with pig irons of a widely varying composition and such great flexibility possessed by no other process at present known. Whereas in the acid Bessemer and acid open-hearth only irons low in

phosphorus and sulphur may be used, and whereas Thomas irons must contain at least 1.7 per cent phosphorus, any irons suitable for the above named processes may be worked in the basic open-hearth furnace and also those which are intermediate between these two extremes. Although it would be unwise to assert that all these irons can be handled with equal facility or economy, we can say, however, that all could be converted into the highest class steel by the basic open-hearth process provided the necessary precautions are taken in manufacture. The author will endeavor in what follows to indicate some of the means which have been developed for accelerating the output and improving the quality of basic open-hearth steels under the different operating and economic conditions met with in various steel making centers.

A steel works is primarily run with the idea of earning a reasonable return on the capital invested in the undertaking and the higher the return the more successful is the enterprise. As the work done in the melting shop forms an important and essential step in the chain of operations requisite to convert the crude ore into steel in a marketable form it follows that it has a big effect on the actual cost of production of the finished steel and hence on the margin of profit available under varying market conditions. The principal items of melting shop costs naturally assume different potentialities in the various circumstances which are to be found in practice and should and generally do influence the nature of the plant put down and methods used in any particular case. The author trusts he may be excused stating these very obvious facts but as they form the reference point from such a subject should be considered he felt constrained to emphasize them.

As liquid metal is used to a considerable extent in large steel works at the present time it will be as well, first of all, to briefly consider the role played by the pig iron mixer in modern works practice.

Table 1—British Steel Output 1918, by Processes.

	Ingots tons	Castings tons	Total tons
Acid			
Open hearth	3,880,949	103,731	3,984,680
Converter	754,899	48,858	803,757
Electric	78,791	46,657	125,448
Stock converter.....	643	13,075	13,718
Tropenas converter....	10,870	53,633	64,503
Total acid.....	4,726,152	265,954	4,992,106
Basic			
Open hearth.....	3,986,926	9,899	3,996,168
Converter	550,500	665	551,165
Total basis	4,536,769	10,564	4,547,333
Total acid and basis	9,262,921	276,518	9,539,439

Table 2—Extensions to Steel Works in Great Britain. Authorized by the Ministry of Munitions, 1916-1918.

	New O.H. Steel Furnaces		
	Basic	Acid	Total
Scotland	31	8	39
Northeast coast	21	3	24
Lincolnshire	9	..	9
Midlands	38	10	48
South Wales	14	5	19
Cumberland and Lancashire.	17	10	27
Total	130	36	166

*Ministry of Munitions Reports.

Mixer Practice.

In most manufacturing operations some kind of an equalizer or buffer is desirable between the important processes in order that the smooth working

of the plant as a whole may not be unduly prejudiced by minor irregularities in the operation of any of the components. As is well known the blast furnace is an uncertain and capricious apparatus, and hence, it is not surprising that early experience with "direct" metal in Bessemer practice soon directed attention to the need of some such buffer between the blast furnaces and the steel plant. Thus arose the idea of an intermediate storage vessel or mixer of relatively large capacity into which the various casts from the blast furnaces could be poured, giving in this manner a metal of more regular composition for the converters and at the same time by providing an adequate store of molten metal, assuring the uninterrupted operation of one Bessemer plant. When the use of liquid metal

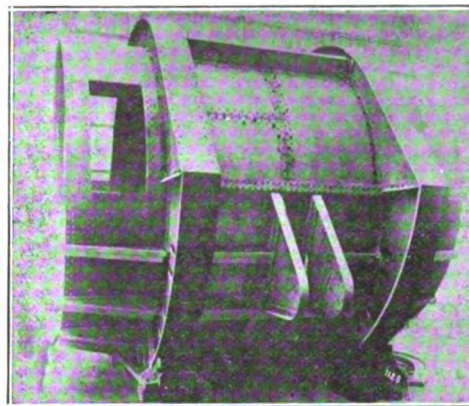


Fig. 1.

in open-hearth practice developed, the advantages of flexibility in operation afforded by the mixer were quickly appreciated, and nowadays a mixer of some form is an essential part of the equipment of every steel works using molten charges.

Functions of the Mixer—As has been said the early mixers were introduced solely as storage vessels or equalizers, and they were for the most part entirely unheated. However, it was not long in being discovered that considerable desulphurization could take place in such mixers under certain conditions, especially with the manganiferous iron used in Continental Thomas practice*. This led to the employment of the mixer to regularly reduce certain of the elements in the pig iron such as the silicon and sulphur, which line of development has been carried considerably further in this country than on the Continent and U. S. A., until many of the mixers now working here are really continuous preliminary refining furnaces.

Gradually the mixer came to play another important part in works practice. With the general adoption of liquid metal in a steel works and the absence of pig casting at the blast furnaces during the week, the disposal of the week end iron became a serious problem as a large labor force would be necessary to handle this product, for which no work could be found during the remainder of the week, it became necessary to seek some rational solution. On the Continent and perhaps to a lesser extent in North America and the United States, the mixer has been increased in capacity until it can take care of practically the whole week end make of iron, thus dispensing with the greater amount of the pig bed work.

*J. Massenez, Journal I. & S. Inst., 1891, No. 2, page 76.

The Development of Mixer Practice at Home and Abroad—The general trend of practice in this country is towards the employment of active mixers provided with heating apparatus of sufficient capacity to permit of a relatively large amount of refining being carried out as well as affording facilities for remelting certain quantities of cold pig and oven scrap. On the Continent and United States, inactive mixers predominate. These merely fulfill the original objects for which the mixer was introduced, but are usually of large capacity and so capable of acting as receivers for the bulk of the week end iron. In many cases they are unheated, whilst in others some simple heating device is applied, which is useful not only in preventing excessive skulling, especially towards the end of the campaign

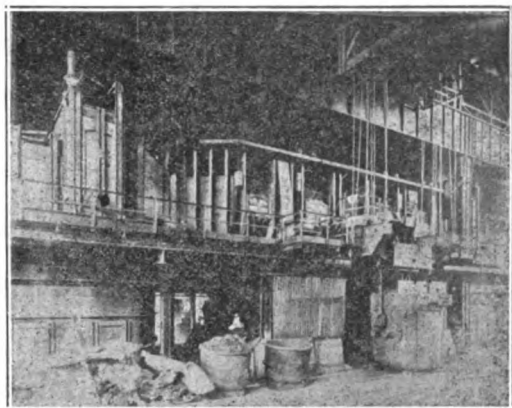


Fig. 2.

of the lining, but also of much assistance during the preparation of the vessel for work.

The reason for this divergence in practice is largely on account of the nature of the irons produced in the different countries. At home the usual product of a blast furnace running on basic iron is in chemical composition and physical condition a very undesirable material to put into a steel furnace. Some rectification of such metal is virtually essential if the conversion costs are to be kept down to a reasonable figure. In continental works there usually exists a closer co-operation between the blast furnace department and the steel works, and in consequence the iron produced is generally of a more suitable quality for steel making purposes, and hence requires little or no preliminary treatment beyond storage and perhaps a certain amount of de-sulphurization which can be readily accomplished in an inactive mixer. It is extremely doubtful if many continental steel makers would even look at some of the pig metal steel works in this country have to deal with. In Table 3 are given a few typical analyses of the blast furnace metal produced in various Continental and American works, and the author well knows what some British melting shop managers would give to have regular supplies of such pig iron to work with. This data is, however, only half the story, as the physical condition, i. e., temperature of the metal is of equal importance, and this matter is generally given all the attention it deserves abroad, whereas here, there appears very considerable room for improvement in most works. In many cases apparently it is the object to produce the pig iron as cheaply as possible without fully taking into consideration the effect of this policy on the costs of the subsequent operations in the steel works and

in this way the economy realized at the blast furnace frequently becomes a serious loss to the works as a whole.

Inactive Mixers—Early inactive mixers were of the converter type, hydraulically tipped. Such vessels present some advantages for small units, up to 300 tons capacity, but beyond this the horizontal cylindrical mixer is to be preferred and this latter type only will be considered in further detail.

The gradual increase in the daily output of steel works, coupled with the desire to do away with pig bed casting at the week end, has resulted in a large increase in the capacity of inactive mixers. While the original mixers installed at Braddock, Hoerde and Barrow were rated at 80, 70 and 150 tons respectively, there are mixers in operation at the present time in the states, of 1,500 tons capacity. On the Continent also some large units have been put down. For instance, there are three mixers of 1,200 tons each at the Bruckhausen Steel Works† and there is one of 1,400 tons capacity at Nilvange, in Lorraine. Generally speaking, unless the works have a capacity of 2,000 tons or more per day, very large mixers do not give satisfactory results as units of more moderate dimensions, 700 to 900 tons capacity when new. M. Jacques, in his admirable treatise on steel works practice‡, writing from wide experience suggests that the capacity of the mixer when new be fixed at approximately 18 hours production of the steel plant for the greatest allround efficiency in operation. With mixers designed to hold a larger amount, the radiation loss becomes excessive towards the end of the working week when the level of the metal is low, this becomes accentuated towards the end of the campaign of the mixer when the lining has been considerably reduced in thickness. To give an idea of the variation in the contents of a mixer during an average working week Table 4 has been prepared. It will be seen that the mixer is only completely full on Sunday night, and after then the level of the bath sinks continuously until the steel works shut down at noon on Saturday.

The general construction of a typical modern inactive mixer of 750 tons capacity, is as follows: The cylindrical body is built up of 1¼-inch steel plates, well riveted together and suitably reinforced by girder section stiffeners. The roller paths are also of built-up construction, they completely encircle the body and while giving the requisite strength to the structure are lighter and cheaper than the cast steel paths formerly employed. The body is carried by four pairs of articulated rollers, thus ensuring an even distribution of the load. Tilting is effected by four single acting oscillating cylinders the rams of which are coupled to forged steel brackets attached to the body end plates. Electric tilting gear is frequently met with in Continental and American practice. The lining of the body is composed of firebrick and magnesite brick, the former for the roof and backing, and the latter for the parts in actual contact with the metal. In the region of the slag lime where the wear is most severe it will be seen that the thickness of the basic material has been sensibly increased. Two principal openings in addition to the ports at either end are provided—the pouring spout and the charging mouth and these have suitable firebrick lined covers to retain heat. The heating in this instance is by no

†Stahl und Eisen, 1911, No. 10.

‡Idées Générales sur les Installations d'Acieries et de Gros Laminiers, Vol. III, Chap. 5.

means of cold blast furnace gas, and a simple recuperator (not shown on the drawing) preheats the air for combustion. The gas and air ports are carried in a movable block to facilitate repairs. Of course other fuels could be equally well used, such as producer and coke oven gases or a tar spray, depending on the condition existing at the works in which the mixer is to be installed.

The appearance of the shell of a modern mixer is well shown in Fig. 1, which is a shop view of a 700 tons unit designed and constructed by Messrs. Wellman, Seaver & Head (now the Wellman, Smith Owen Engineering Corporation) for the Pont a Vendin Steel Works.

As has already been pointed out, inactive mixers are employed principally as storage vessels, no great amount of chemical refinement being aimed at. Nevertheless, with good blast furnace metal, having a sufficiently high ratio of manganese to silicon, an appreciable percentage of sulphur can be readily removed. To show the possibilities in this direction, Table 5 is given, which has been prepared from data on the operation of a 900 tons inactive mixer over a period

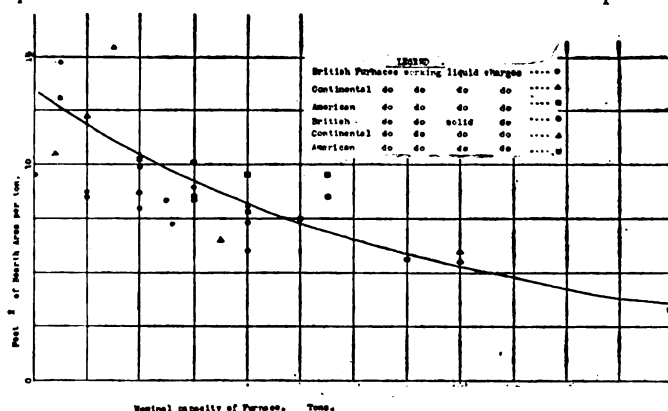


Fig. 3.

of several months recorded in Prof. Simmersbach's valuable paper on pig iron mixers⁸. It should be remembered however that the mixer proper is only responsible for about 50 per cent of the reduction effected, the balance taking place in the ladle during transit between the blast furnace and the steel works.

The life of the lining of an inactive mixer naturally varies somewhat with the general operating conditions of the plant in which it is working, and the quality of the refractories employed. A 1,000-ton mixer through which about 2,000 tons of pig iron are passed per day would have a campaign of about nine months.

Active Mixers—The line of demarcation between active and inactive mixers is difficult to define, and no hard and fast rule can be laid down, as it is entirely a question of degree. For the purpose of this paper however, a mixer will be considered as being of the active type when it has the regular regenerator equipment of an ordinary melting furnace. Such a mixer will be able to carry out a considerable refining of the blast furnace metal as sufficient heat will be available to permit an oxidizing slag being maintained.

Owing to the greater wear and tear on the linings of active mixers and consequent heavy maintenance costs, their capacity is restricted to a much smaller figure than would be permissible for inactive mixers.

Anwendung in Eisenhüttenbetriebe.

Dr. Peterson in the course of his able essay on basic open-hearth practice⁹ expresses the opinion that the capacity of active mixers should not exceed 300 tons and certainly the majority of mixers of this type put down on the Continent do not materially exceed this size. Experience at home points to 400 tons as about the maximum capacity it is desirable to concentrate in one unit where any larger amount of refining is to be carried out. The author has in mind an active mixer of 500 tons, which he believes to be the largest in operation in this country. Although this big unit has given satisfaction, it would appear unwise to increase the capacity much beyond this figure.

The resemblance between a modern active mixer and a large tilting open-hearth furnace is striking, and in some works one may find a pair of practically identical furnaces, one of which is turning out finished steel, while the other is only refining the blast furnace metal. Fig. 2 is a view of a very fine active mixer of 400 tons nominal capacity. It is one of four put down at Messrs. Bolckow Vaughan & Co's. Cleveland Works by the Wellman, Smith, Owen Engineering Corporation. This mixer is fired by ordinary producer gas, and tilting is effected by two double acting hydraulic cylinders.

The first cost of such mixers is a heavy item—the author knows of a 400-ton unit which has recently been put down at a cost of over £100,000, and the working costs are also considerably higher than with simple inactive mixers. So that once having decided to install an active mixer in a works it is essential to make the best use of the facilities it affords for increasing the production of the steel furnaces, for in no other way can the large capital outlay involved be justified. However, the possibilities in this direction are wide, and in most British steel works using ordinary basic iron, the employment of active mixers yields profitable results on account of the unsuitability of the pig for direct conversion into steel, principally on account of its high silicon content, which causes excessive wear on the hearth of the steel furnace and prolongs the time required for working a heat owing to the increased slag formation. Also the sulphur in most basic irons is on the average higher than can be tolerated in steel for many purposes, and the mixer is a convenient apparatus in which to effect a considerable reduction of this element, which as most people know is somewhat difficult to eliminate regularly to any great extent in the steel furnace without much loss of time. Unfortunately, when oxidizing the silicon and sulphur a part of the manganese will also be removed, but, under good conditions the ratio of the silicon to manganese will decrease. Table 6, compiled from the author's observations on the operation of a 300-ton mixer, at a leading British works, indicates the amount of the refining that can be expected in regular works practice, but it should be added that during the time these observations were made, the mixer was working under very unfavorable conditions, being too small for the number of furnaces it was feeding, and the pig metal, owing to irregular working of the blast furnaces, left much to be desired.

The active mixer capacity installed in different works varies between wide limits, as may be gathered from an inspection of Table 7, which gives leading particulars of the mixer plant in various European

⁸Stahl und Eisen, 1911, No. 10, Roheisenmischer und ihre
⁹Stahl und Eisen, 1910, Nos. 1 and 2, Zum hertigen Stande des Herdfrischverfaahrens.

works, together with some data on the steel furnaces supplied and approximate compositions of the pig iron and mixer iron under normal circumstances.

Before passing on to a consideration of some of the metallurgical aspects of our subjects, a few words on basic open-hearth melting furnaces will not be out of place.

Table 3—American and Continental Irons for Basic Open-Hearth Work.

District	Percentage Composition				
	C.	Si.	S.	P.	Mn.
E. Pennsylvania.....	3.7	1.0	0.06	0.08-0.10	0.40
Pittsburgh	3.9-4.1	0.5-0.9	0.04-0.07		0.8-0.9
Styria	4.0	0.1-0.3	tr.-0.03	0.08-0.10	2.0-2.5
Westphalia	3.2	0.3-0.5		1.8	1.5
Lorraine		0.6	0.06	1.8	1.2
Moravia		0.7	0.06	1.1	1.7
S. Russia	4.2	1.0		0.16	1.9

Table 4—Variation in Contents of a 750 Ton Inactive Mixer During the Working Week.

Steel works take 1,000 tons of pig iron per day for 5½ days.

Blast furnaces produce at the rate of 900 tons per day for 5½ days and at 831 tons per day for 1½ days.

Days	Time	Received		Contents of Mixer
		from B. F.	To O.H.F.	
Sunday	22.00	750		750
Monday	22.00	900	1,000	650
Tuesday	22.00	900	1,000	550
Wednesday	22.00	900	1,000	450
Thursday	22.00	900	1,000	350
Friday	22.00	900	1,000	250
Saturday	12.00	450	500	150
Saturday	22.00	345		496

Metal to pig bed = 650 tons (maximum).

Melting Furnaces.

Although the main principles of open-hearth furnace design remain the same as when established by the late brothers, Siemens, there has been a gradual but persistent improvement in detailed construction which has resulted in the realization of possibilities in the directions of increased output and efficiency

undreamed of 40 years ago, and which have made the open-hearth furnace the most convenient and suitable apparatus we possess for the economic production of structural steels, a position long held unchallenged by the Bessemer converter.

Table 5—Elimination of Sulphur in a 900 Tons Inactive Mixer.

Month	Ave. Comp. of B.F. Metal			Ave. S. in Mixer Metal	Elimination of S. pc
	Si. pc	S. pc	Mn. pc		
December ...	0.66	0.070	1.78	0.047	32.7
January	0.75	0.073	1.49	0.053	27.4
February	0.70	0.084	1.70	0.066	21.4
March	0.77	0.073	1.83	0.047	35.6
April	0.56	0.075	1.62	0.057	24.0
May	0.59	0.085	1.64	0.058	31.6
June	0.67	0.081	1.97	0.056	30.9
July	0.57	0.071	2.02	0.044	38.0
August	0.575	0.062	2.03	0.041	33.8
September ...	0.575	0.060	2.10	0.043	27.4
October	0.775	0.059	2.10	0.041	30.5

Table 6—Example of Operation of 300 Tons Active Mixer. Mixer Heated by Blast Furnace and Producer Gas.

Blast Furnace Metal			Mixer Metal			Elimination in Mixer		
Si. pc	S. pc	Mn. pc	Si. pc	S. pc	Mn. pc	Si. pc	S. pc	Mn. pc
1.54	0.035	2.45	0.93	0.03	1.40	39.5	14.3	43.0
2.10	0.030	2.30	0.56	0.029	1.42	73.1	3.3	38.2
2.24	0.027	2.30	1.07	0.026	1.87	52.1	3.7	18.7
1.40	0.068	2.10	0.70	0.032	1.60	23.6	53.0	28.8
1.26	0.031	2.80	0.33	0.029	1.56	73.7	6.40	44.3
1.59	0.034	2.34	0.98	0.022	1.92	38.4	35.3	18.0
2.15	0.020	2.70	0.93			43.2		
Mean =						49.1	19.3	38.2

The primary requirement of a melting furnace is the capability of maintaining an exceedingly high temperature, and it may almost be said that the flame temperature cannot be too high, provided it is under control, for in the open-hearth process as in many other thermo-chemical operations the efficiency realized is a function of the average temperature attainable rather than of the heat units generated, for the temperature determines the degree of availability or effectiveness of such heat units. The furnace however, must also be capable of supplying a sufficient

Table 7—Data on Active Mixer Practice at Various Open Hearth Steel Works.

Country and Dist.	Particulars of Mixer Plant			Forces Supplied From Mixer		Type	Av. pc of mixer metal in charge	Blast Furnace Metal				Mixer Metal			
	No.	Capacity	Fuel	No.	Capacity tons			Si. pc	S. pc	P. pc	Mn. pc	Si. pc	S. pc	P. pc	Mn. pc
Austria, Moravia	1	300	Producer gas	1	200	Talbot*	95								
						Wellman	87	0.7	0.06	1.1	1.7	0.21	0.04	1.1	0.95
						Fixed	75								
England, East Coast..	1	400	Blast Furnace gas	1	100	Talbot	90								
				2	175	Talbot	90	0.5-1.0	0.04-0.12	2.0	1.5				
Scotland	2	250	Producer gas	4	60	Fixed		1.4	0.07	1.85	1.75				
England, Midlands....	1	500	Mono gas	1	40	Wellman	80-100								
				3	80	Wellman	80-100	1.5	0.08-0.3	2.0	1.0-2.0	0.5	0.06	1.8	0.6
England, North West	1	300	Prod. & B.F. gases	4	50	Fixed									
	1	250	Prod. & B.F. gases	3	80	Fixed									
				4	75	Fixed	50-75	1.6	0.04	1.30	2.30	0.70	0.03		1.60
England, Midlands....	1	400		9	50	Fixed									
				1	60	Fixed	50	0.9-2.0	0.08-0.09	2.0	2.0	0.70	0.04	1.6	1.5
Italy	1	300	Prod. & C.O. gases	5	55	Fixed									
Germany, Hanover....	1	150	Blast Furnace gas	5	40	Fixed†						L	L	L	L
	1	250	Blast Furnace gas			Fixed									
Germany, Silesia.....	1	150		4	30	Fixed	40								
France, Est.	1	300		3	60	Wellman									
				2	25	Fixed									
North Wales.....	1	300	Prod. & C.O. gases	4	30	Fixed	60-80								
				4	40	Fixed	60-80								
England, North West	1	250		4	50	Fixed‡									
England, N.E. Coast..	1	400	Producer gas	4	80	Wellman	90	2.5				1.0			
				6	60	Fixed									
England, Midlands....	2	250	Producer gas	2	30	Fixed§									
				3	45	Fixed									

number of heat units per minute in the period of the "chardure"* to melt the solid components of the charge, raise the whole bath to the tapping temperature and supply the heat necessary to maintain the endothermic reactions as well as balance the radiation losses from the furnace structure. Then having assured an adequate heat supply to work the proposed charges in the allotted time the next matter is to endeavor to make the life of the furnace as long as possible by giving due consideration to the general construction and to the selection of suitable refractory materials for the different parts, in order that the cost of production may not be adversely affected by a very heavy repair bill, and finally it should be the aim of the furnace builder to make a furnace give consistently good results during its life, that is to say, the output should remain practically constant throughout the campaign. It is as well to mention at this juncture that the present state of the art of furnace construction is largely due to the improved refractories now at our disposal, together with a better understanding of the principles governing their successful employment under different conditions. But improvements in this direction are far from being at an end and much important research work is being carried on in this and other countries which should result in a very material betterment in the general qualities of the known refractories and perhaps also in the introduction of entirely new materials.

Open-hearth furnaces may be divided into two main classes: those with stationary hearths and those in which the hearth is capable of being tilted or rocked. Fixed furnaces largely predominate at the present time and the author considers that it may safely be said that under most conditions they will yield a better return on the capital investor in their construction than the much more costly tilting furnaces. Broadly speaking, these latter have developed in two directions. Firstly for units of very large capacity intended to work the Talbot or duplex pro-

cesses of steel manufacture, and secondly, for furnaces of more moderate dimensions in which it was desired to accelerate the rate of steel production by removing a certain proportion of the slag several times during the working of a heat, which could be readily accomplished in a tilting furnace. Recently however, a simple and inexpensive apparatus has been devised whereby it appears possible to fully realize this advantage in ordinary fixed furnaces without incurring the heavy expenditure involved in the installation of tilting furnaces. Of late years there has been a marked tendency to put down these small tilting furnaces in new British plants and this tendency is also noticeable in Continental practice. In the states only the large units for duplex work appear to be favored, fixed furnaces being adopted in almost every other case.

The capacity of steel furnaces has greatly increased during the last 15 or 20 years and at the present time the average size of fixed and "small" tilting furnaces lies between 60 and 100 tons, while large tilting furnaces for the Talbot and duplex processes, where only a portion of the total contents of the furnace is tapped out at a time, are built in capacities ranging up to 250 tons. In the States also, there are some fixed furnaces working charges of as much as 170 tons⁷. In many works the 60—75-ton furnace is the most suitable unit to put down, all things taken into consideration. The prompt handling of a cast of this weight is an engineering feat of no mean order, and the working up of the ingots produced makes sufficiently heavy demands upon the soaking pit and blooming mill facilities of a plant if the initial heat of the steel is to be utilized to the fullest extent. In the author's opinion it is more in the direction of regularity of

*This word was coined by the late Mr. Alleyne Reynolds to convey the same idea as the German word "chargendauer", which means the period from commencement of charging to emptying the furnace. See Dichmann's Basic Open Hearth Steel Process, page 123.

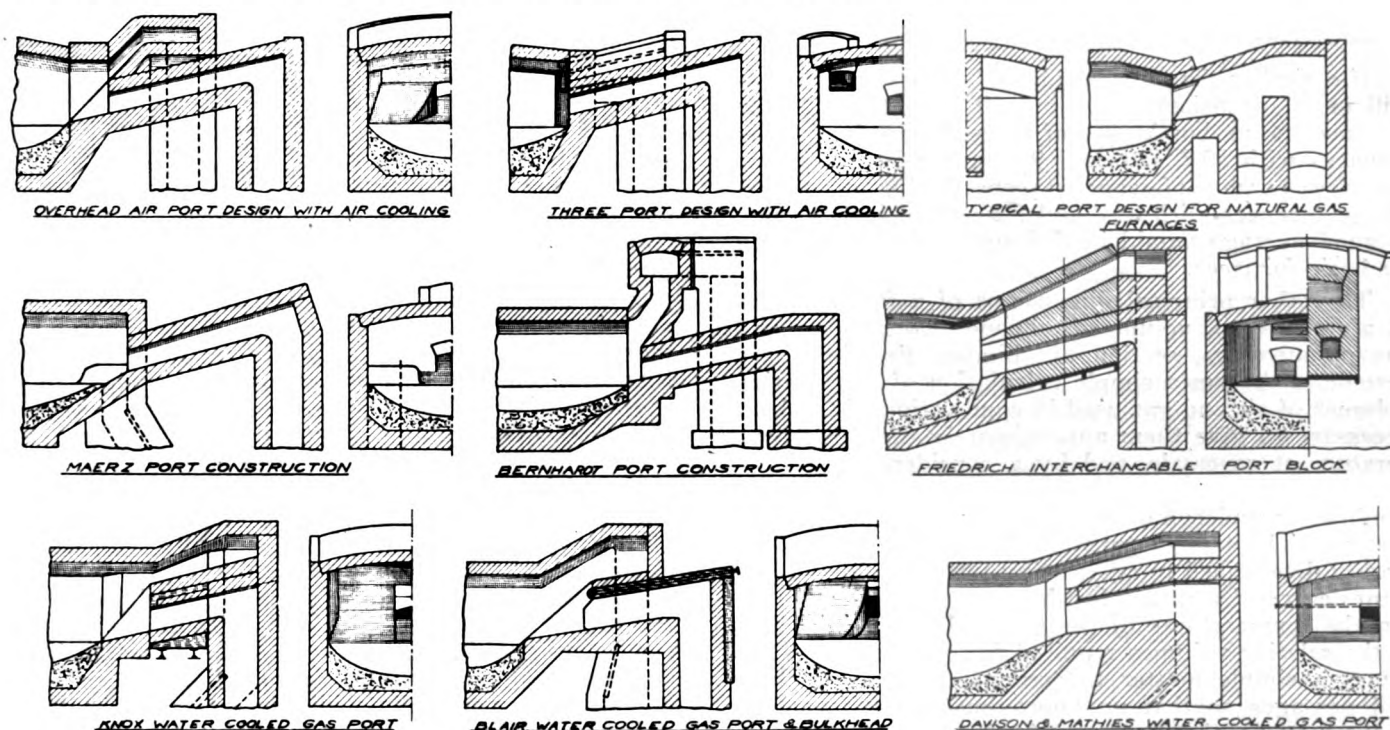


Fig. 4—Various ports employed in open hearth furnaces in England.

operation that room exists for considerable improvement, as by a greater degree of uniformity in the sequence of the tapping times of furnaces a better progression of ingots through the soaking pits and blooming mill could be secured, than when, as is frequently the case, several furnaces tap almost immediately after one another, thus overwhelming the pits with ingots they have not the capacity to deal with, with the result that many must be allowed to go cold before accommodation in the pits can be found for them, with consequent increased fuel consumption and general loss of efficiency. Of course it would be virtually impossible in open-hearth work to reach the degree of precision attainable in Bessemer practice, but the nearer a melting shop can be run to a definite schedule the better for the works as a whole.

A glance over the drawing of various open-hearth furnaces will reveal considerable differences in the proportions selected for the chief elements of the design even in furnaces of the same rated capacity intended to operate under approximately similar conditions. Such a state of affairs can only have arisen from a neglect to give attention to the fundamental principles on which the design should be based. However, there are two leading dimensions which are only obtainable from practice, viz., the hearth area per ton of steel capacity and the gas port area. In both these considerable variations are to be met with, many influences affecting the choice of dimensions in a given case, hence it is well to know as completely as possible the conditions of operation of the furnace selected for comparison. Fig. 3 shows the relation existing between the hearth area per ton of nominal capacity for several fixed basic furnaces, some working liquid charges, others solid charges, in successful operation at home, on the Continent and in the States. This diagram given an idea of the variation found in furnaces of the same nominal capacity. A curve has been drawn on the diagram to indicate good average proportions for different sized furnaces. Generally speaking, furnaces working liquid charges should have more generous hearth dimensions than cold charged furnaces on account of the greater slag formation.

If a similar diagram be plotted for gas port areas still more inconsistent results will be obtained. For instance the author knows of three 40-ton fixed basic furnaces with 50.2, 23.8 and 9.3 square inches of gas port area per ton of capacity respectively, and of two 50-ton furnaces with 21.7 and 5.2 square inches each. A good average would be 5-6 square inches per ton for basic furnaces.

The other principal dimensions of a furnace such as air port area, volume of chequer work in air and gas regenerators, section of chimney flues etc., are best derived from a simple calculation of the relative volumes of air and gas used in combustion of the heat necessary to give them approximately the same temperature at reversals, and by a consideration of the changes of temperature these and the products of combustion undergo on their way through the furnace system. The temperatures at different points can be readily determined in an existing furnace with a sufficient degree of accuracy for the purpose. Then, knowing the temperatures of the gas and air at inlet and of the relative volumes required for combustion it becomes a simple matter to arrange the various flues and passages so that an approximately uniform velocity may be obtained, and further that the correct ratio between them be preserved. An excellent paper

by Mr. Bagley* deals with this and other aspects of furnace design in an admirable manner.

Having briefly outlined the basic principles of design we will now pass on to a short consideration of the constructional features of modern furnaces.

The Hearth Side Walls and Roof—The hearth in the best practice is now carried directly on steel or concrete columns leaving a clear space underneath the furnace for slag bogies. The hearth is frequently encased in a heavy riveted steel plate pan resting on transverse girders, which in turn are carried by longitudinal girders bearing on the columns above mentioned. This pan is lined with two or three courses of basic refractory bricks, upon which the working bottom proper is built. There are several ways of making up the bottom and as costs can be largely influenced by the capacity of the hearth lining to withstand erosion and the action of fluxing agents, any time taken in making a really good job of it is well spent. In many English works the bottom is built up by sintering layer upon layer of crushed dolomite or magnesite mixed with a small proportion of basic slag, until the required form is attained. Such bottoms when carefully made give excellent results, and have remained in for five or more years. In Germany it is frequently the practice to make the bottom by stamping in a mixture of dolomite and hot anhydrous tar, much in the same manner as preparing the "plug" for a Thomas converter, and then heating the furnace, first by hearth fires and later by gas until the entire mass is burned hard. A method of rapidly building up a satisfactory basic bottom, developed at the Lankashire Steel Works during the war, is described in a paper by Messrs. Gray and Smith* in the following terms:

"The greater part of the banks and a large portion of the bottom are rammed in with tar and dolomite—the best anhydrous tar procurable being used and care being taken to secure dolomite which shows no signs of perishing. This operation on an average occupies four shifts. The gas is then put on and when a sintering temperature has been reached the bottom and banks are coated with layers of dolomite burned on, after which the hearth is thoroughly slagged. The whole operation including the period of heating up occupies about 100 hours and yet bottoms made in this fashion give satisfaction though from none has ever been asked such lengthy service as is apparently frequently demanded elsewhere."

The back wall of a basic furnace, especially in liquid metal practice is exposed to more severe conditions than the corresponding part of an acid furnace owing to the fluxing action resulting from the splashing of the bath with its basic slag whenever a fresh pan of material is dumped into the furnace by the charging machine and also during the pouring in of the pig metal. While it is the general practice to construct the wall of silica brick from a point just above the level of the slag line, on the Continent basic material is frequently carried up much higher than this, often up to the last two or three courses under the roof, and in addition the wall is built with a considerable outward batter. In the States basic back walls of magnesite brick have been experimented with a good deal without yielding the results hoped for, but a new basic brick enclosed in a sheet steel jacket and known as "Metalkase" brick, has been employed at some works with great success. The essential difference between magnesite brick and a "Metalkase" brick is that the former spalls, while the latter does not, and it is this quality which enables "Metalkase" brick to last from two to three times as long as magnesite

brick. In general, they are laid with the ends exposed to the heat, and as the furnace approaches the melting temperature the ends of the cases become converted into oxide of iron and fuse with the magnesite. Each brick burns fast to those adjoining until the entire wall becomes a solid unit.

Furnace roofs are nowadays nearly always carried independently of the side walls by means of special skewback bricks seating in channels or I beams bolted to the buckstays. The old custom of allowing freedom for expansion of the roof by adjustable tie rods is no longer universal, and many large furnaces are now working with rigid roofs, and these, if properly built in the first instance give better results than the old type. In the States, a roof known as the Orth, after its inventor, having reinforcing ribs running across it at fixed centers, is used to a considerable extent. When the brick work between the ribs has worn away, these latter still give the structure sufficient strength for a further lease of life, and in the event of a hole developing, special blocks are provided which seat on the reinforcing ribs and make a satisfactory repair.

The Ports and Uptakes—The direction and form of the flame is essentially dependent upon the direction and form of the gas stream from which it is renewed as well as upon the velocity of the latter. It is the function of the ports to control the air and gas streams, and hence they play a vital part in the working of the furnace. The gas port especially is worthy of careful attention. Its length should be such that even when burned back considerably it is sufficient to guide the gas stream and so keep the flame going true in the direction of the longitudinal axis of the furnace, as when it swerves either towards the side walls or towards the roof the destruction of those parts is rapidly accomplished. Its inclination, also an important matter, should cause the flame to impinge directly upon the surface of the bath at a reasonable distance from the face of the port, as only by this intimate contact can the best results be obtained from the gas.

The air port or ports should be arranged to secure a thorough mixture of the air and gas as soon as they are free to unite in order that combustion may take place as rapidly as possible.

The solid port block found in many British furnaces appears prejudicial to a long life of the gas port, as owing to the mass of material in the block and the intense heat, the refractories are in a highly unfavorable conditions to withstand the powerful eroding action of the waste gases as they sweep into the exit ports. In the States these defects are largely ameliorated by the extensive application of water cooling to the roofs of gas ports and in some cases to the sides as well, and thus enabling them to keep true to shape almost indefinitely. These water cooled devices are, however, somewhat costly, and for that reason apparently have not found wide employment in European practice. On the Continent much effort has been expended in improving the life of ports by air cooling and good results have in some cases been achieved by this method at considerably less expense. In Fig. 4 are shown diagrammatically some of the principal forms of ports met with in present day furnaces, and attention is particularly drawn to the Maerz port, which combines many desirable features.

The uptakes can be made larger in cross section than the ports, always keeping them in the same rela-

tive proportions, to reduce friction and wear, and by decreasing their velocity the waste gases will deposit a larger percentage of the solids carried in suspension and less of the finer particles will find their way into the chambers. The slag pockets, a distinctive feature in modern furnace construction, assist materially in maintaining the output of the furnace during its campaign. In the States one or two types of removable pockets have been introduced, and these, if in other respects practical, are a step in the right direction.

(To be continued)

THE BASIC OPEN HEARTH PROCESS.

(Continued from page 30)

because of the improving methods of putting in bottoms and introduction of magnesite, so that the initial charges of 60,000 pounds became 90,000 pounds.

The year 1890 gives us the first reliable survey of the new and growing process in the United States and in addition to the Homestead Works, there is shown to have been the following plants producing steel by the basic open hearth process:

The Steelton Works of the Pennsylvania Steel Company, using a combination of the acid-bessemer and basic open hearth processes.

The Henderson Steen and Manufacturing Company, at Birmingham, Ala.

The Southern Iron Company, at Chatanooga, Tenn.

The Pottstown Iron Company, at Pottstown, Pa.

Mr. Swank estimated the production of the process in the United States, including that made by the duplex process, for the year 1890 at 90,000 tons out of a total for all open hearth steel of 513,232 tons. This total production was the output of 47 plants in 10 states. The tremendous growth of the process and proof of its predominant influence in creating the great steel output of this day can be seen from the following tonnage figures:

Relative Production of Steel for Year 1914.

	Bessemer		Open Hearth	
	Acid	Basic	Acid	Basic
United States.....	6,220,846		903,555	16,271,129
United Kingdom..	797,072	482,444	3,680,848	2,874,749
Germany	100,617	8,169,183	274,321	5,946,215
France	82,393	1,658,758		1,146,167

Product in United States for 1918.

	Bessemer		Open Hearth	
	Acid	Basic	Acid	Basic
	9,376,236		1,982,820	32,476,571

Development of Furnace Lines.

In reviewing the developments and comparing the tonnages produced per heat, (which in every case are those obtained finally from the hearth of the furnace under normal conditions, since nearly all furnaces produce finally a tonnage larger than the rated tonnage) as against the bath depths, areas of bath at the slag line and the regenerator volumes etc., we find, aside from the growth in furnace capacities, with which all are familiar, the following characteristics:

Bath depths that did not increase relative to furnace capacities and hearth areas, showing the tendencies towards faster working and enhanced oxidation effects.

Increasing areas of bath in which the length was the predominant factor in effecting the change, so that the length increased much faster than did the width.

Very little tendency towards the increase of air and gas pre-heating capacities per ton of steel produced in the case of gas

producer furnaces. Much greater capacities for preheating the air in the case of natural gas furnaces.

Many improved devices and methods for preserving and lengthening the life of the furnace have been evolved during the period of furnace development up to the present time. Of these we may mention devices for water cooling the ports, bulkheads, skewbacks, back and front walls, doors and door frames, buckstays, valves, and dampers; air cooling systems for slag pockets, regenerative chamber walls; systems for reinforcing the roof by means of ribs formed of special or standard shapes; removable cinder pockets.

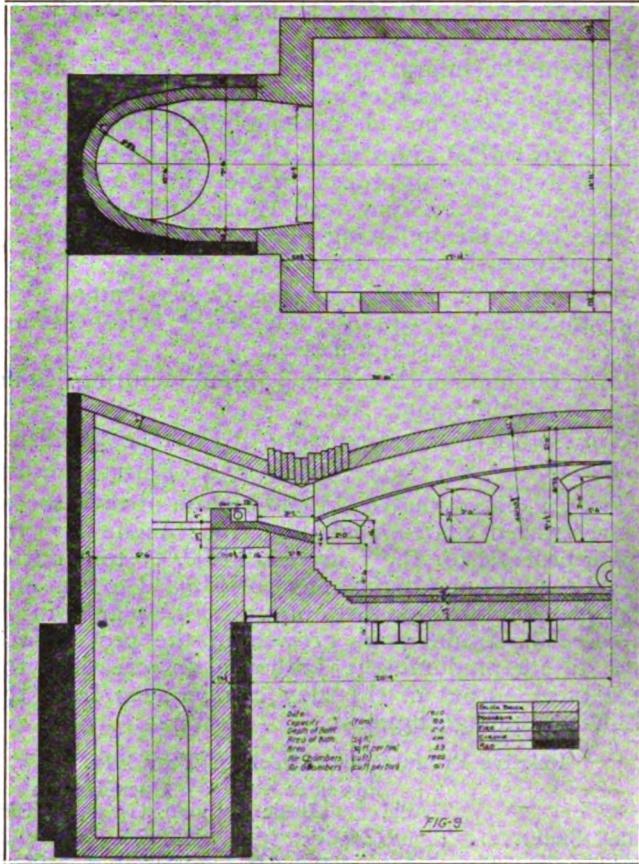


Fig. 1—The largest natural gas furnace built and of the type used in the plant holding the world's monthly record at the present time for a fourteen furnace plant.

It may be said that certain furnace lines have been particularly developed with reference to the most economical working of the furnace and if those lines are altered appreciably or lost by burning out, then the efficiency of the furnace is impaired and its life shortened unnecessarily. In preserving such lines cooling devices are warranted up to the point where the cooling effect begins to lessen the thermal efficiency and further gain in preserving furnace lines seems to have reached the limit. Open hearth furnace men of sound experience express the idea more concisely by saying, "we cool only the vital parts of the furnace."

After many discussions over a period of time by the Carnegie Steel Company Open Hearth Committee along the lines of present developments in basic open hearth plant and furnace design, it appears that the following figures and characteristics show in part what might be considered the best practice at the present time:

Fuel Capacity	100 tons
Distance between levels	20 feet
Furnace bottom	Pan type, 12 in. of sintered magnesite on 12 in. of magnesite brick on 24 in. of fire brick.
Area of bath at slag line	6.5 sq. ft. per ton of steel capacity.
Distance center to center	90 feet.
Height from door sill to skew-back of roof	60 inches.
Roof	Roof body should be straight, arched in one direction with 24 in. spring. Roof thickness, 12 in. Only standard shapes used.
Doors and frames	Water cooled. Doors electrically operated.
Buckstays	Slab type—water cooled.
Front and back walls	Should be supported on water coolers at or near the slag line.
Ports	Semi-water cooled type, cooled at vital points.
Bulkheads	Water cooled.
Air regenerators	A minimum capacity of 68 cu. ft. per ton of steel and a minimum heating surface of 150 sq. ft. per ton. The figures for one regenerator.
Gas regenerators	A minimum capacity of 46 cu. ft. and a minimum heating surface of 100 sq. ft. These figures for one regenerator.
Valves	Area of gas and air valves 10 sq. ft. each.
Damper	Cast iron—inclined—air cooled.
Producers	Mechanically operated—two per furnace. Each producer with capacity for gasifying 60,000 lbs. per day.
Stack	180 ft. height, 6 ft. inside diam.
Waste heat boilers	Yes.
Metal mixer	Unit size, 500 tons capacity. Elliptical shape, fire brick lining.
General—Stock yard to be roofed. Ore, limestone, spar to be kept in bins constructed so as to provide for easy unloading and loading, with no shoveling. Best labor saving devices to be used in repairing furnace and regenerators.	

The above committee recommend that in building the first new open hearth plant, one of the furnaces be laid out so as to give clearances considerably greater than usual. Ample room will be had thereby for the installation and thorough trial of equipment embodying new and advanced ideas, which otherwise must wait for trial in new plants, where in the event of failure to show economy, unnecessary expense in the correction of faults is caused and future trial and development is discouraged. In this way much could be developed in new methods of regeneration, methods of cleaning regenerators and keeping them clean, removable cinder pockets, insulating methods for reducing heat losses, new port constructions, volume control of air, etc., in fact many lines of improvement could be started that have been held back for years by lack of space in existing plants. In the event of further furnace construction, the ideas proving of value could be incorporated so as to give the best possible construction with very little risk of failure.

The Development of Fuels.

The fuels suitable for use in the open hearth furnace have been, from the day William Siemens gasified coal in order to successfully operate his regenerative furnace in melting steel, necessarily those which had a high speed of combustion, giving high flame

temperatures with a comparatively low ignition temperature. With the methods employed so far in burning fuels, high radiation effect has been thought desirable.

Producer gas, has been throughout the development of the open hearth process, acid and basic, the mainstay as a fuel, and furnace development as to size and output has been paralleled and assisted by development in capacity an efficiency of the gas producer. The present trend is to fewer and larger units per furnace, as for example, a 100-ton furnace can be satisfactorily taken care of by two large producers, each with a capacity of gasifying 60,000 pounds of coal per day.

Mechanical feeding, poking, ash handling, careful crushing and screening of coal, careful regulation of blowing have helped to decrease costs of operation. The advantages of the producer are its simplicity and fairly low cost, its limitations are due to the high non-combustible content of the gas with the corresponding low calorific power and the objectionable clogging content of soot and tar. The necessary preheating of gas to obtain adequate flame temperature makes for larger generative systems and more complicated and costly furnaces. The proportion of total fuel gas generated in the producer in the future depends altogether on the growth of the by-product coke industry. There has started a growing replacement of producer gas by coke oven gas with varying amounts of tar. Plants isolated with respect to by-product coke plants must continue the use of producers indefinitely, and for

them the problem of low calorific power, high sulphur, high ash coals must be worked out thoroughly. This will probably mean washing, entailing in general, fine crushing, so that ultimately the use of very fine coal must be carried out successfully in the gas producer.

By-product coke oven gas has developed as a fuel for the open hearth furnace in the United States within the last five years. Considerable work has been done with it in Europe, particularly through mixtures of blast furnace and producer gas with it. As commonly used it is debenzolated, so that it is somewhat less luminous than the raw gas with from 5 to 6 per cent less of heating value. Having a calorific value of half that of natural gas, it possesses nevertheless, at least three times that of producer gas, is much cleaner and has a very low content of inert gases. Like natural gas it can not be preheated without breaking up and possesses similar advantages over producer gas in the elimination of costly gas making and handling equipment at the open hearth plant, making more simple the port, uptake and cinder-pocket construction, and making possible greater volume for regeneration of the air. It is in general thought necessary to use tar in amounts dictated by practice or amounts available, for the purpose of giving luminosity to the gas flame. The usual procedure is to blow the tar as atomized by air or steam, through the end walls of the furnace, immediately over a jet of coke oven gas. The whole burner arrangement is cooled by a water jacket so as to be able to maintain the desired position and inclination of the burner.

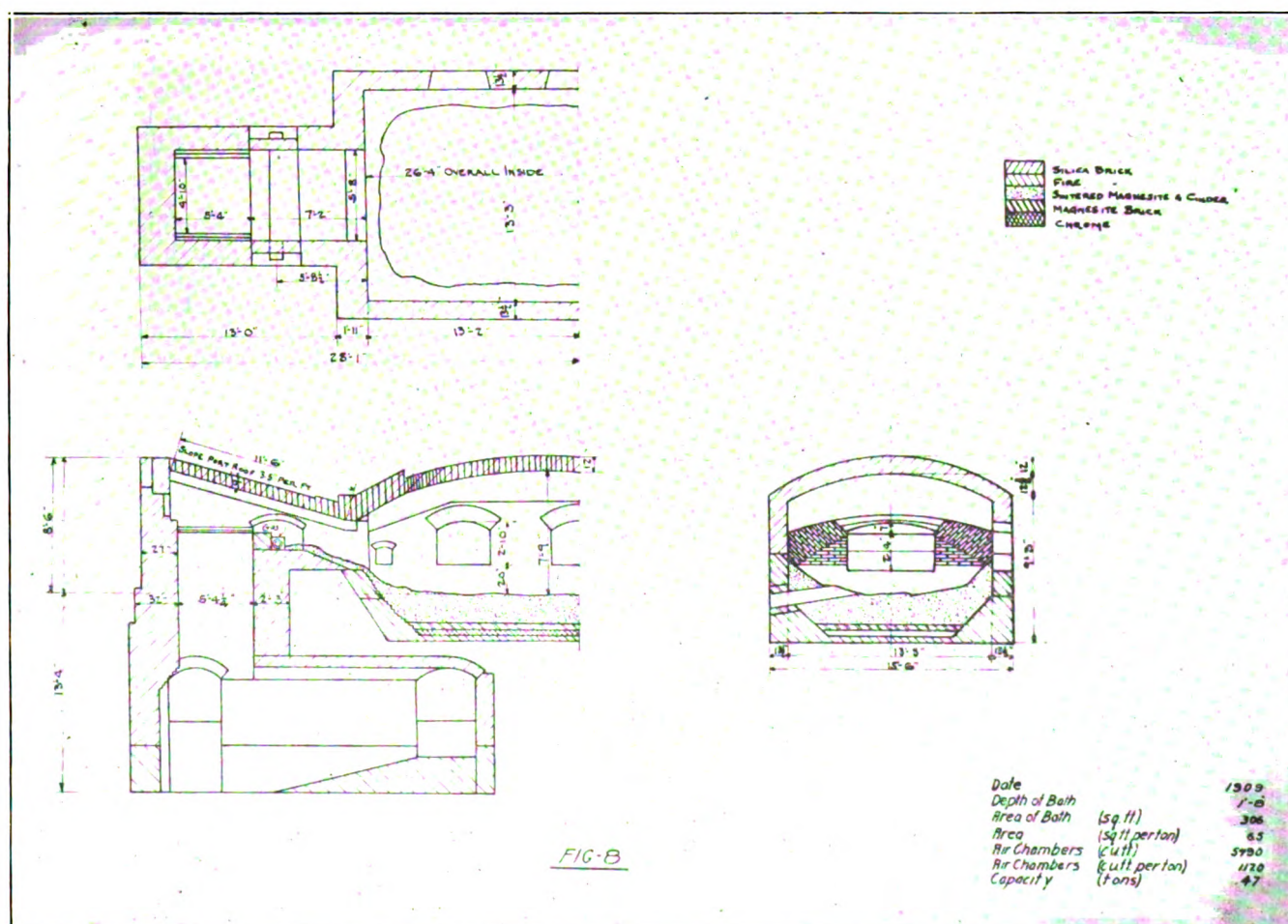


Fig. 2—A greatly simplified port construction. This furnace is the very best type of natural gas furnaces, making heat in exceptionally fast time and with a short flame of very high temperature very easily controlled.

For considerable periods during the last 18 months, practically straight coke oven gas has been burned at the No. 3 open hearth plant of the Homestead Works, Carnegie Steel Co., with but small loss of tonnage as compared with natural gas, through the same burners and without the use of tar. The greater cost of furnace repairs, although small, would warrant however a study of the situation with the object of shorter flames, better flame control and an earlier ignition. The Duquesne Works have also had a period of successful use in a producer gas type of furnace as compared to their producer gas practice. In both cases above the gas enters at right angles to the air volume. The problem of burning coke oven gas seems to be in the early stages of solution and promising as it looks at present as a fuel, there can be undoubtedly much greater efficiency in burning, with incidental attainment of higher flame temperatures with the flame placed and kept where it will give maximum effect. Ultimately we must learn it without the added luminosity of burning tar vapor which will require much education as to flame temperatures on a new standard of flame color, together with a better mixture of air and gas; also methods for obtaining earlier ignition and for direction of gas so as to give practically its full calorific effect along the bath and before the gas can rise to burn along the roof or at the outgoing ports or downtakes.

There is hardly a doubt but that the growing effort to obtain the maximum from coal and to conserve its by-products will make for an increasing use in the by-product ovens rather than in the gas producer. Even should the demand for by-product gas by municipalities tend to the point where coke is produced in surplus, it must be borne in mind that blue gas produced from coke has a calorific value double that of producer gas, a low volume of inert gases, is stable, and free from soot and tar and can be used as a coking fuel for by-product ovens and for furnaces where high radiation effect is not necessary and direct heating desirable.

The quantity of tar produced in the by-product ovens bears a fairly close relation to the volume of gas produced and the question of its over-production in the growing scale of magnitude of by-product coke operations may arise. The excellence of tar as a fuel not only in the open hearth furnace but also in heating furnaces and under boilers makes the possibility of its overproduction remote. The present surplus over the needs of the tar refiners is used as before stated, in combination with coke oven gas or, as in several plants, is used alone as a fuel in a manner similar to that for fuel oil, employing air or steam, particularly the latter, to atomize the tar and convey it into the furnaces. The burners are usually placed in the end walls, following the system used for oil. Great care must be taken to maintain sufficiently high temperatures by means of steam coils in storage tanks and supply lines, to avoid the deposition of pitchlike material which quickly clogs up the supply system. There are possibilities through better atomization and flame control by means of improved burner design, towards the attainment of very economical fuel consumptions as estimated on the Btu per ton basis.

Fuel oil in its various stages from crude oil to residues dates in its use as open hearth furnace fuel back to the introduction of the basic process into this country. It is a most convenient fuel, particularly for

small plants. Its high temperature and easy control makes it suitable for fine steels or work in foundries where high tapping temperatures are necessitated by numerous shutoffs in pouring and thin intricate castings. Of late the quality and amount of fuel oil passed over for fuel uses in metallurgical industries by the refiner and the high sulphur content of many of the oils has made the use of oil both expensive and troublesome. It cannot rank as a major fuel and its supply is doubtful for steel making.

Powdered coal has been used in a number of open hearth plants continuously as a fuel for a number of years and has had extensive application for short periods in others, where acute shortages of natural gas and lack of space for gas producers made the powdered coal fuel appear as the best relief. Powdered coal, even so fine as to pass almost entirely through a 300 mesh sieve, burns slowly as compared to gases. The extremely high velocities of injection into the furnace used in the past have prevented economical burning and have tended much towards the burning out of the brickwork on the outgoing ends. Lower velocities of introduction, volume air systems, use of primary air, have given the fuel a much better chance to burn efficiently in the furnace. Preheating the air for combustion adds greatly to furnace efficiency and speed. Admitted that the powdered coal burning is of late showing much more promise, the problem of the ash, which greatly complicates the regenerating system and interrupts the furnace operation must be solved. Powdered coal systems must in the future take their share of high ash, high sulphur coals as must the gas producer. The cost of pulverized coal at the furnace is cheaper than that of producer gas for equal prices of coal. Steel has not been made with powdered coal fuel as cheaply as by average producer practice. Powdered coal is still in a stage of evolution, and gives promise of replacing gaseous fuels in many processes.

Natural gas, associated so prominently with the first stages of the basic open hearth process in this country, is the finest fuel as yet obtainable for the purpose of steel making. The next two years will no doubt find its use restricted to the domestic consumer with a growing demand for coke oven gas by the cities and towns.

General Efficiency of Furnaces.

We can speak with pride of the place the open hearth furnace has taken in filling economic needs, but as a conserver of man power and of fuel and of its efficiency in general and particularly from a scientific standpoint, we must speak apologetically, having seen so little of it manifested. There has been a sort of apathy towards improved labor saving installations and a lack of desire for fuel burning efficiency and heat conservation as regards the open hearth process.

The blast furnace, already a much more efficient process, has been given a very much greater amount of constructive effort in this direction and the reward has been in the more ready solution of fuel and ore problems as they continue to arise.

From reliable observations made in the very few plants where thermal efficiency was deemed of sufficient importance to warrant thorough investigations and a staff for that purpose, we can get an idea of the very large field for improvement and the economies possible. Very reliable investigations made at the Homestead Works and already quoted from before the

Iron and Steel Institute by William Whigham, show us the following: of the total heat available in the open hearth furnace, 14.16 per cent is in the steel at tapping, 3.3 per cent in the slag, 2.78 per cent is used in reduction of ore and calcination of limestone. 62.45 per cent leaves the outgoing port to enter the checker chambers, 22.93 per cent is absorbed by the checkers, 4.53 per cent is absorbed between the checkers and stack, and 34.99 per cent is carried up the stack. Radiation and conduction losses would total 17.31 per cent.

The thermal efficiency of the regenerators, based on the ratio of the heat given up to the air and gas as against the total heat return to the regenerators, ranges from 20 to 38 per cent.

The first consideration must be to get a greater return from the heat passed on to each unit of the furnace. The burning of the fuel so as to melt the charge more readily, to promote heat transfer to the steel and slag, and with complete combustion over the hearth, must be the first and most important achievements.

In comparing and reviewing gas burning systems, that condition which stands out most is the fact that our ports are a compromise to suit both conditions of entry and exit, so that the tendency is almost universally to make the area of the ports too large for the incoming air and too small for the outgoing products; also, in producer gas furnaces, for gas velocity to greatly exceed the air velocity through its port, a condition bad for rapid combustion and high flame temperatures. Our flames are usually too long and start too far from the entering port.

In furnaces of present design the mixing of air and gas depends on the inclination of the air to gas port, the extension of the air port beyond gas port to give the air access to the gas before entering the furnace chamber. It has been thought necessary to provide a heavy air blanket above the gas, so that the gas, being lighter than the air would at least burn before it rose to a point where its combustion would damage the roof. Much better is a mixing of air and gas in the port so that combustion will start and finish while the flame still has direction along the top of the bath. The products can then rise and expanding fill the furnace chamber, giving their heat to bath and brickwork without damage to the latter. This, provided there is sufficient port area on the outgoing end. Another condition, as yet hardly appreciated, shows flames approaching too closely the outgoing end, thus incomplete combustion. We have for years taken stack samples, found excess oxygen and no carbon monoxide and have concluded that combustion was completed—in the hearth chamber. Careful sampling and analysis of gases from outgoing ports at several of the Carnegie Steel Company's plants, lead to the conclusion that condition of incomplete combustion may exist at the outgoing port, whereas the stack sample may show complete combustion due to the completion with excess air provided by leakage into the regenerator chambers, flues and valves. If we have had an excess of oxygen as so frequently stated it has been applied in the wrong place.

The first step towards the efficient use of fuel is to give the flame direction and this depends on the slope of the port roof, the size of the port opening and the velocities of the air and gas. The next step is to supply the necessary oxygen in such a manner as

to provide a thorough mixture and produce a short, hot flame. Air supplied under forced draft in combination with a system of contracting the incoming port area while at the same time enlarging the outgoing port area and vice versa on reversal of flow, helps greatly in providing the above desirable conditions and would allow the admission of air directly into the gas port as with natural gas burning. Such relations have been illustrated in principle in 1912 by C. A. McCollum, of the Homestead Works, and stated by him, in a report covering the efficiency of a furnace, as necessary with forced draft and desirable under all conditions.

The visible evidences of the embodiment of the above principles will be a shorter and hotter flame, quicker melting, more easy heating of slag and steel, less temperature variation in the bath at the ends from one reversal to another, and finally a much longer life of furnace brickwork.

To those who fear that conditions which so help combustion may make for over-oxidation in producing fine steels, it may be said that conditions of good flame control coupled with better combustion will make finally for more certain furnace control in obtaining either an oxidizing or reducing condition as desired.

The blast furnace stove is from 50 to 100 per cent more efficient than the open hearth regenerative chamber. One of the reasons for the difference is the horizontal chamber of the open hearth furnace as against the vertical type where the air rises naturally and gets full benefit of all the area. More volume is necessary for regeneration than is usually given, due to the cramped space usually allowed for the regenerators. By deepening the chambers and using a chamber more nearly vertical in action, double the number of chambers could be put on the same area of ground space, affording thus two extra chambers at each end for use in the system as the chambers in use clog up. By placing vertical regenerators of much greater height (or stove pipe) near the stack some of the efficiency and long service of the blast furnace stove could be obtained, and at the same time plenty of chance for deposition of dust in the flues. Much of the hard drudgery of cleaning out and relaying regenerator brick can be saved by future planning and construction and at the same time a greater return of heat units from the furnace obtained with all the advantages of greater preheat in gaining fuel economy. The advantages of being able to put into service clean chambers as the ones in service choke up, irrespective of time of furnace repair, and those of having regenerative systems that are in good condition over many furnace runs are certainly worth trying for. Since regenerator brick are in general designed to withstand the frequent handling and relaying without breakage, being therefore thick, and being laid in a manner which usually sacrifices efficiency for a longer run because the more frequent the checker removals, the greater the delay showing on furnace repairs, then a development in regenerator design will open up to us to a greater extent the advantages of thin brick with their quicker heat transfer and absorption, and systems of laying more nearly adjusted to the laws of gases.

The amount of heat loss by radiation and conduction raises the question as to the means of adding to the thermal efficiency of open hearth furnaces by reducing their losses. The use of thick walls and roofs

is open to the objection of excessive melting action on the brick due to the greater amount of heat retained; to the increased accumulations that result; and there has been determined by practice in many cases a maximum thickness of brickwork, for which the radiation losses are balanced by the beneficial effects of cooling in preserving the brick. To suit such conditions there is necessity for development along the line of increased refractory quality in the brick, together with better insulating qualities in cutting down the amount of heat transmitted.

Portions of the furnace system not subject to the high temperatures adjacent to the hearth and ports, as for example the regenerative system and flues, may well be made the subject of experiment as to the effect of better heat insulation, following the line of work being carried out in reference to blast furnace stoves. This would tend to further efficiency in the regenerators and add to the economy of the use of waste heat boilers.

Since from 35 to 45 per cent of the total heat delivered to the furnace is wasted to the stack a recovery of 60 per cent or more by means of waste heat boilers is a paying investment. Their use is a well

developed feature of many plants and is particularly economical in the case of gas producer furnaces with their large volume of waste products. With natural or coke oven gas as a fuel, not over 80 per cent as much steam can be generated as on the producer gas furnace. The fans in connection with boilers are materially beneficial in the latter part of the furnace runs in promoting furnace draft.

Allowing for all of the improvements made in mechanical equipment for handling both charge and product, for all those made in furnace design and structures, we have still very serious problems in furnace efficiency and also in the application of improved furnace design and labor saving methods to the problem of eliminating manual labor. The latter object must be obtained not only by making the final furnace repair less difficult but also by means taken to prevent "choking" up during the furnace run and to obtain less frequent repairs while maintaining furnace efficiency. To these problems the open hearth man, the engineer and manager should give very serious attention, and all must realize that there is with them an ever present obligation to solve these problems for the good of all.

Electric Furnace Improvements in 1920

One of the Principal Improvements During the Year Has Been
the Introduction of a New Automatic Current Regulator With
Movable Electrodes.

By A. G. AHRENS.

THE electric furnace, having firmly established itself for making alloy steels and steel castings is now rapidly coming into use for melting the non-ferrous metals, particularly brass. Electric furnaces are also being used to melt iron for special iron castings and undoubtedly its use in this way will increase in the future.

Increasing use of alloys in tool steels has stimulated production of ferro-alloys. New alloys such as ferro-sirconium are being made, and the electric furnace is now the recognized medium for making ferro-alloys.

An item of interest in connection with the operation of arc furnaces is the effort to increase production by forcing a large amount of energy into the furnace during the melting period. This necessitates larger electrical equipment with two operating voltages, because the high voltages used during the melting period cannot be used during refining. There is a difference of opinion regarding the advantage of dual voltage operation. In furnaces up to 2-ton capacity, the greater expense of installing double voltage transformers and switching equipment does not seem to be justified, while in larger furnaces there is some question whether the quality of the metal is affected by a high rate of melting. This would be of importance where tool steel is made. Some furnaces are being installed with two operating voltages from making castings and their success is a matter of great interest.

One of the principal improvements in the electrical equipment for electric furnaces has been the introduction of a new automatic current regulator for arc furnaces with movable electrodes. This regulator has

high electrode speed combined with high precision of regulation, both with absolute freedom from hunting. Power peaks are reduced with this regulator and it is possible to place the furnace on automatic control immediately at the start of the heat, and hand control is not required during the initial stage, as has been necessary in some cases in the past. Because of this, the time of melt-down can be reduced, and this in turn increases production and reduces cost of power per ton of steel produced. Each electrode is controlled independently of the others and it is impossible for an electrode to get into the steel, which minimizes electrode breakage.

INSTALLATIONS OF THE YEAR 1920.

During the past year a number of notable installations were made in various plants throughout the country. Among the prominent Heroult electric furnace installations for ingot making were: One 6-ton furnace for the Atlas Crucible Steel Company, Dunkirk, New York, and one 6-ton furnace for Henry Disston & Sons, Inc., Tacony, Pa. There are now a total of 99 Heroult furnaces used in the United States for making ingots and 73 for making castings. The Booth Electric Company have to date sold 12 steel melting furnaces, 40 of which are their new rotating furnaces used for the melting of brass. Detroit Electric Furnace Company have 82 furnaces built to date, five of which are foreign installations. These are a few of the installations which the prominent electric furnace companies made during 1920.

Gases Obtained in Molten Steel

Dealing With the Gases Which Manifest Themselves During Steel Making Operations—Classification of the Gases and How to Deal With Them in Order to Make the Product Sound.

By HENRY D. HIBBARD.

PART I.

THE gases of steel offer an attractive field to the investigator, particularly those which manifest themselves during the steel-making operations, in the furnace and molds. Some study has been made of gases obtained from steel in various ways, but none of the results have been of much benefit to this man in the shop. He wants to be able to deal with the gases of molten steel so as to make his product sound, for it will be readily admitted that gas-holes are in a way defects and must at least, be kept at a minimum in all steels whatsoever.

The gases dealt with herein are particularly those of steel made by an oxidation process, chiefly by the open-hearth. The steels will be divided into three classes according to the treatment of their gases in the making, namely: (1) Steels made by methods which favor the free escape or evolution of gases from the metal in the molds causing effervescence which will be called effervescing, or evolution steels; (2) Those from which the escape of gas is prevented as completely as possible in the molds, and which if permitted will pipe or settle, which will be called solution or killed steels and; (3) Those whose gases are neither wholly evolved nor wholly kept in solution which will be called partly-killed steels.

Effervescing steels have low carbon, under 0.40 per cent. They should neither rise nor settle in the molds but the ingots should have flat tops and no pipes. The bulk of the low carbon steels made in the United States is effervescing steels.* Effervescing steels in which the gases are not kept in solution nor yet made to give proper effervescence are made though they should not be.

Killed steels tend to settle as they solidify and form cavities at the top of the ingot or casting known as pipes or settle holes. They may be of any carbon in the steel range.

Partly killed steel may settle, some may stand or rise while solidifying according to the degree to which it is killed. That which rises in the mold is not to be recommended for any purpose as the extent of its rising plus the volume of the pipe it would have it completely killed is the measure of the total volume of undesirable gas-holes within its mass. Most steel for rails is partly killed.

Much that has been written about the metallurgy of steel, while perhaps of interest to the scientist is of but slight use to the working metallurgist, usually because the information given is incomplete, and most writings relating to gases are not exceptions to the rule. One wants to know the history of a steel under consideration, whether it was defective or not and if so, the reason. In the absence of definite information it is perhaps proper to assume that it was of a certain commercial grade and quality and that the generalizations made are applicable to such steels alone.

The word "blowhole", commonly used to designate a cavity formed by gas in steel would better have been

"gashole" but is now too strongly established by custom to be displaced. The quiet gradual formation of a gashole in metal which evidently occurs, does not correspond to the idea of blowing as does a jet of steam or of gas entering the metal from a too moist or too hardly rammed sand mold from which the name was, undoubtedly, derived.

Gases in molten steel may be considered as produced (1) by the combination of the carbon of the metal with oxygen from the air or from oxide of iron in contact with it, (2) by decomposition of aqueous vapor by the molten iron with liberation of hydrogen

This is the first part of the article written by Henry D. Hibbard on the "Gases Obtained In Molten Steel." The next two parts will appear in the February and March issues. This paper is based on experiences of the writer with open hearth furnaces in this country and abroad. Following the conclusion of this article Mr. Hibbard will write upon numerous other open hearth metallurgical problems, as he has just recently been appointed to the Advisory Board of THE BLAST FURNACE AND STEEL PLANT magazine.

which is absorbed, or (3) by absorption of nitrogen from the air. It is likely that reactions taken place within the metal between the hydrogen, nitrogen and carbon by which hydrocarbons, cyanide and ammonia, some or all of them, are formed.

All real gasholes in steel are formed by gases expelled from and enclosed in the metal at the moment of solidification or soon thereafter, as the saturation point of each gas is passed, the separating gas being entrapped by the freezing steel. Any gas which separates and forms a bubble in actually liquid steel must quickly rise to the top. Other gases, namely steam and hydrocarbons sometimes form real blowholes in steel castings being generated from water or organic matter in the mold material by the heat of the metal and then entering the steel usually from below.

Though we can deal with the gases of steel practically with some success we ought to know more of their composition, quantity, how they are made, how they get into the steel, degrees of solubility in the metal at the different temperatures and in the presence of the various ingredients of steel. The appearance of the steel and slag, molten and solid is still the chief source of information concerning them and the addition of solvents or decomposers the chief means of dealing with them aside from the furnace manipulations. The activity of the boil from a given carbon,

*See paper on effervescing steels by author American Institute of Mining and Metallurgical Engineers, volume 52, page 160.—8 pt. footnote.

and quality of the slag, both in the bath and as a cold sample, tell the story of the gases in the furnace, while the tops of the ingots tell if the steel rose or not. However, if the ingot is so dead that it does not rise, the killed and partly killed steel cannot always be distinguished from each other by the eye.

Referring now to killed steel, to insure the absence of gas-holes from an ingot or casting requires that none of the saturation points of the gases contained shall be passed before the metal has solidified. The actual amounts of the gases and of the solvents contained does not decide the point. The latter may be high and the metal still contain gas-holes. It is the relative amount of solvent to gas which is important, that is, there must be in the steel more than enough solvents to keep the gases present in solution if gas-holes are to be absent. Steel may contain such amounts of gas-solvents as have been present in other steel that made solid castings and yet be exceedingly unsound. The oft-referred-to excessively hot-blown Bessemer steels containing from 0.6 per cent to 1.5 per cent of silicon and yet very gassy and with many blowholes in the ingots are cases in point. Much smaller percentages of silicon are enough to quiet and kill well-made steel when molten and perfectly solid ingots when cast. Apparently such a too hot Bessemer heat may acquire a "temperature above the dissociation point of silica when the oxidation of the silicon will cease while the carbon burns freely and forms carbonic oxide (CO) gas. Hydrogen from moisture in the blast, which is decomposed and its derivatives, charges the silicon with all the gas that it can hold. Then as the temperature of the molten steel falls the solvent power of the silicon decreases and the gases separate accordingly. Those which do so and are entrapped in the freezing metal form and occupy gas holes which are exceedingly numerous in such steel.

The relative solvent power of the usual elements which enter into steels is shown in the following list in which the most powerful is given first and the weakest last: Aluminum, silicon, titanium, calcium, vanadium, manganese, chromium, tungsten, nickel and copper. The solvent power of the last four, if any, is not great enough to be useful. It is probable that these solvents have different powers over the different gases of steel, and each should be used understandingly to deal with the gases present when knowledge of the matter has become adequate. These solvents (so-called) prevent the escape of CO gas by preventing its formation or by decomposing it. It is a matter of indifference to the steel-maker which way they act so long as by their use he can prevent the formation of CO holes in solution steel. Hydrogen being an element must of course be kept in solution. Nitrogen must probably be kept in solution whether present in the elementary form or combined with hydrogen to form ammonia or in weak combination with iron.

As no way is apparent by which in an open-hearth furnace hydrogen may enter the metal while the latter is molten and covered with slag. A higher carbon bath must evidently contain more hydrogen than the same bath after some carbon has been eliminated as the escaping carbonic oxide presumably carries off with it some of the hydrogen.

The elements used for increasing the solvent power of the metal for gases, should be added after the melting, heating to casting temperature, and all oxidation of carbon has been completed when only a controllable amount of gases will be or should be

present in the metal. These elements as they exist in the usual trade forms and alloys are unsaturated by gases and their surplus dissolving power is utilized. Why an alloy made in the blast furnace, as for instance, ferrosilicon is unsaturated with gas but has instead a large surplus of gas-dissolving power is not explained. The gases it is exposed to in the smelting process are CO, CO₂, H₂O, and N with O just in front of the tuyeres. In the melting furnace the metal is exposed to the same gases but in very different proportions. In the pneumatic converter it is subjected to oxygen, nitrogen, aqueous vapor and in some degree to carbonic oxide (CO). The great difference seems to be in the fact that in the oxidation steel processes the carbon is oxidized partly within the mass of the metal which is a condition favoring the retention in solution of some of the CO formed. The absence of hydrogen from the ferrosilicon still lacks explanation.

The above consideration of ferro-silicon as a blast furnace product supports the view that the solidifying effect of silicon and aluminum in steel is due to decomposition of dissolved CO with the reduction of carbon and formation of oxides of those elements as well as the continued solution of the hydrogen and nitrogen. The too hot and gassy Bessemer heats containing high silicon cited above indicate strongly the same, as in such metal these actions cannot take place.

Many analyses have been made of gases, derived from steel which were practically average samples and the results therefore, shed but little light on the composition of gas in each of the different kinds of gas holes and consequently on the effects of and proper treatment of the gases. These analyses showed the samples collected to be almost wholly hydrogen, nitrogen and carbonic oxide.

Ammonia (NH₃) is often present but not determined and there seems to be some reason for suspecting that cyanogen (CN) and hydro cyanic acid (HCN) should also be included in the gases of steel as they are in the blast furnace products. These last three named are all soluble in water and to determine them the gases should be collected and analyzed over mercury. In studying the subject the analysis of and pressure of the gases in each kind of gas-hole, in each kind of steel should be the first step.

Muller's extensive researches of 1878 and 1879 on gases in cold steel have been of slight practical benefit, largely because he did not discriminate between the different gases and the different kinds of gas holes, nor between the gases in the holes and those in the solid steel. He found gas to be stored as great as eight atmospheres. This pressure shows that gases continue to exude from the metal into the gas holes for some time after freezing and indeed for some time after the metal has become strong enough to prevent further increase in size of the holes. Were the gases in a hole not so augmented after solidification of the steel a partial vacuum would exist therein because of the rarification due to the high temperatures of the gas which formed it. To have eight atmospheres in a cold hole the pressure in it must have reached a maximum of about five times as much, when evolution of gas ceased, due to the hot state of the gases or 600 lbs. per square inch. To withstand this pressure the steel may have cooled to 1300 degrees or 1350 degrees C. inversely according to the carbon.

By weight the quantity of gases in gas holes is an extremely small part of that of the steel. Assuming

an ingot to have 1 per cent of gas holes by volume a pronounced though not uncommon amount and that the gas in the holes has an average specific gravity of one fourth that of air its weight compared to that of the ingot will be expressed by the quantity:

$$\frac{8}{773 \times 4 \times 7.9 \times 100} = \frac{1}{305335}$$

773 is the weight of water compared to air.

4 is the specific gravity of air compared to the gas in the holes.

7.9 is the specific gravity of the steel.

8 is the pressure of the gases in the holes expressed in atmospheres.

The total gases of the steel in question may have been much more as some may have escaped and some be retained in solution. In good effervescing steel the quantity in the gas holes is insignificant compared to that which has escaped in the molds. The weight of the gases retained in solution is extremely small and the final addition of one or two hundredths of 1 per cent of aluminum overcomes any tendency they have to separate in well-made killed steel, so that gas holes are not formed.

Considering as a whole the gases in liquid steel or decarbonized iron which is to be made into steel, there are four courses, one of which they may take: (1)

They may be evolved and so escape from the metal: (2) They may be held in solution until it is solid and cold: (3) They may, if compounds, be decomposed by reducing elements added or, (4) They may occur in gas holes which they have formed, or in any settle hole or pipe cavity in the steel. The first course is followed in making effervescing steel and the second in making solution steel already referred to. High carbon steels and steel castings should be made by the solution method. A middle course in which a part only of the gases which do not escape are held in solution will yield partly-killed steel well charged with gas holes.

Classifications of the Gases.

The gases of steel may be classified as follows:

1. Gases in and evolved from molten decarburized iron.
2. Gases in and evolved from molten steel.
3. Gases which occupy gas holes and pipe cavities in steel.
4. Gases which remain dissolved in cold steel.
5. Gases which are evolved from heated steel.
6. Gases which are evolved when steel is acted upon by water, acid or other chemical.

These will be considered in order.

(Continued in next issue)

Refractories and Their Relation to Furnaces

Consideration Upon Which the Proper Selections of Refractories Depend in Order to Increase the Earning Power—Physical as Well as Chemical Composition Must Be Considered.

THE earning power of a furnace depends upon the judgment and care exercised in the selection of the correct kind and quality of brick for each of its parts, and equally upon the care with which the masons do their work. An 80-ton furnace will contain about 1,000,000 brick, while a 40-ton furnace will require about 700,000. The expense of the masonry is a serious item, as that is the part of a furnace which most often requires renewal. The total output of the furnace is dependent on its durability. Thus a shut-down of say two weeks for relining and repairing an 80-ton furnace means a loss of output of about 2,500 tons of steel. In the meantime the overhead expense goes on.

Considerations on which the selection of refractories depend are:

1. The working temperatures of the various parts of the furnace.
2. The nature of the materials with which it will come in contact.
3. The slag whose chemical action it must resist.
4. The scouring action of the impinging flame and gases.
5. The hot and cold static loads and arch thrusts imposed.
6. The abrasion to which it will be subjected from metal or slag.

The functions of fire brick are to form a chamber and passages to contain and conserve the heat of the fuel and hold the metal and slag of the bath. In an acid open hearth silica brick are used for the bed, sides, roof and ports of the furnace. The hearth is made of silica sand sintered into an impervious mass.

The life of a well made acid furnace will approximate one thousand heats.

In a basic furnace magnesite is used in place of silica for the bed and sides at the slag line, although chrome brick is occasionally used for the sides. Under a great heat chrome brick yields to the compression due to the weight of the walls and roof above it.

Much experimenting has been done to find a cheap suitable basic material for a basic furnace which is reasonably abundant in this country. General practice favors a sintered bed of magnesite glazed over with dolomite.

For basic furnaces much caution should be exercised in departing from the standard practice of using the best magnesite. Experience during the war and the recent steel strike has developed the fact that in a number of instances in furnaces of average large size the dolomite bottoms had slacked to such an extent as to necessitate their replacement by magnesite.

The best practice calls for at least one or two courses of magnesite brick laid on the steel bottom of the furnace. On top of this the grain magnesite is built up by sintering to the required thickness and shape of bed in which the charge is melted and steel refined. On account of the cessation of imports from Europe during the war the supply of the best magnesite (which comes from Austria) was cut off. Various substitutes have been tried. One of the best

Abstract taken from "The Open Hearth," published by the Wellman-Seaver-Morgan Company of Cleveland, O.

of these is a magesian compound called "syndolag." A silica sand or a magnesite which is chemically too pure or free from impurities will not "sinter" successfully. Therefore for acid furnaces an impure synthetic silica sand is used, having the following analysis:

Table 53.

	Per cent
SO ₂	97.25
Al ₂ O ₃	0.16
CaO	.18
MgO	.40
Alkali	.36
H ₂ O	.24
Ignition losses	.36

The value of refractories for furnace work is determined not alone by chemical composition, but also by their physical attributes.

In the substitutes for Austrian and Greek magnesite which are used, the body of the material is dolomite mixed with iron oxide, mill scale or ore. These oxides retard the slaking of the dolomite, but reduce the refractoriness of the dolomite. Good results have been obtained by some of these substitutes used in hearth making or patching.

An efficient substitute for magnesite brick is found in "metalkase" brick. These are a basic or neutral brick of oxide of magnesia enclosed in an open end thin cylindrical or square steel shell. The open ends are laid exposed to the flame in the furnace. The brick are laid in a pulverized magnesite mortar. Under the furnace temperature the brick shells oxidize and fuse with the magnesite forming a solid mass of the furnace lining. These brick have a long life as spalling does not occur, nor is the fused combination of magnesite and iron oxide attacked by the iron oxide vapors from the bath, as is the case with silica brick. When additions to the bath are made, especially of hot metal, the violent boiling of the metal splashes the walls with slag and metal. In the case of silica brick this causes severe erosion, but has little effect on the metalkase brick. Another place of severe and rapid wear are the silica gas port bulkheads, due to the erosion of the very hot gases carrying oxide of iron. An evidence of the durability of magnesite and metalkase is given in the working of a 250-ton furnace. The magnesite backwalls lasted on an average of 450 heats. Metalkase when used lasted 1,400 heats.

The hardness of burning in general is a factor worthy of consideration, although firing to a high temperature can not, in the nature of the case, effect any fundamental change, and cannot convert a low grade material into a good one. Experience has shown that well burned bricks stand up better than soft burned products. Refractories cannot be fired at too high a temperature. The superiority of high fired over low fired ware from every standpoint, especially as regards change in volume when part of the furnace wall is so striking that every effort should be made to push to the maximum possible burning temperature.

In regard to the fluxes present in a clay, the state and size of grain of the iron is of importance, for it is evident that coarser grains of iron minerals will do no harm.

A clay with a high volume shrinkage subjects the structure of the products into which it enters to a severe strain, which, owing to the low tensile strength, may cause serious difficulty owing to cracking and checking. It may be necessary either to calcine the flint before incorporating it in the body, or to replace it in part by ground waste brick (grog). At cone 14

of the Seger series of temperature measuring cones the shrinkage show as follows:

Table 54.

	Per cent
Pennsylvania flint (Clearfield County).....	5
Maryland flint	5 1/3
Kentucky flint	9 1/4
Ohio flint	9
Moxahala flint	3 1/3

A clay with a low fire shrinkage gives a product with a minimum of internal stresses and strains, of high tensile strength and one that will stand up well under heat and load conditions.

If a fire brick is dark colored, it probably contains a considerable proportion of iron oxide. This may or may not be a disadvantage, according as the iron oxide is in a fine or coarse state of division. Very finely divided iron oxide acts as a flux, but the coarser iron sulphides (pyrites) which occur in fire clays form coarser grains, which do not have so serious an action on the refractoriness of the clay. Consequently, a brick which is very spotty will probably be more refractory than one which is more uniformly red or brown. The proportion of iron cannot be ascertained from the color of the brick, as a finely divided material will produce a greater amount of color than will coarser particles. Repeated analyses of a well known brand of fire brick have shown that any attempts to judge the amount of iron from the appearance of the brick is most misleading. As no fire brick are entirely free from iron oxide, any attempts in this direction are necessarily futile.

The quality of fire brick depends largely upon the case exercised in making, burning and cooling of fire brick. The strength falls off rapidly as the temperature increases, hence fabrication defects become quite serious at high temperatures. The need of a severe inspection of open hearth furnace brick is shown by the following figures:

Table 55—Tests of Silica Brick Arranged According to Resurces.

Pres. under which bricks were made, lbs per sq. in.	Apparent specific gravity	Impact inches	Percentage spalled	—Slag penetration sq. ins.—		
				Open hearth slag	Heating furnace slag	Expansion linear inches per foot
187	1.50	47	45.5	3.48	2.28	0.155
500	1.58	46	48.3	3.68	2.42	0.155
750	1.59	60	53.2	3.63	2.41	0.158
1000	1.63	65	51.4	3.79	2.42	0.160
1250	1.65	68	47.9	3.65	2.50	0.155
1500	1.66	65	43.6	3.82	2.50	0.160
2000	1.67	67	44.8	3.64	2.45	0.159
2500	1.68	71	42.0	3.72	2.50	0.160

Commercially good brick at 80 degrees F.—2270 pounds average compressive strength.

Commercially good brick at 2450 degrees F.—1170 pounds average compressive strength.

Loss of strength—48.5 per cent average compressive strength.

Defective from fire cracks or poor moulding, etc.—500 pounds average compressive strength.

Loss of strength—78 per cent average compressive strength.

Table 56—Losses by Spalling, Expressed as Percentage Pressure Under Which Bricks Were Made, Pounds per sq. in.

Mesh	187	500	750	1000	1250	1500	2000	2500
4	21.9	34.9	36.9	38.7	31.4	30.0	19.1	29.1
8	51.6	45.9	62.6	51.0	43.3	34.8	38.3	43.3
12	62.9	64.0	59.2	64.4	69.1	65.8	67.0	53.6

(Continued on page 78)

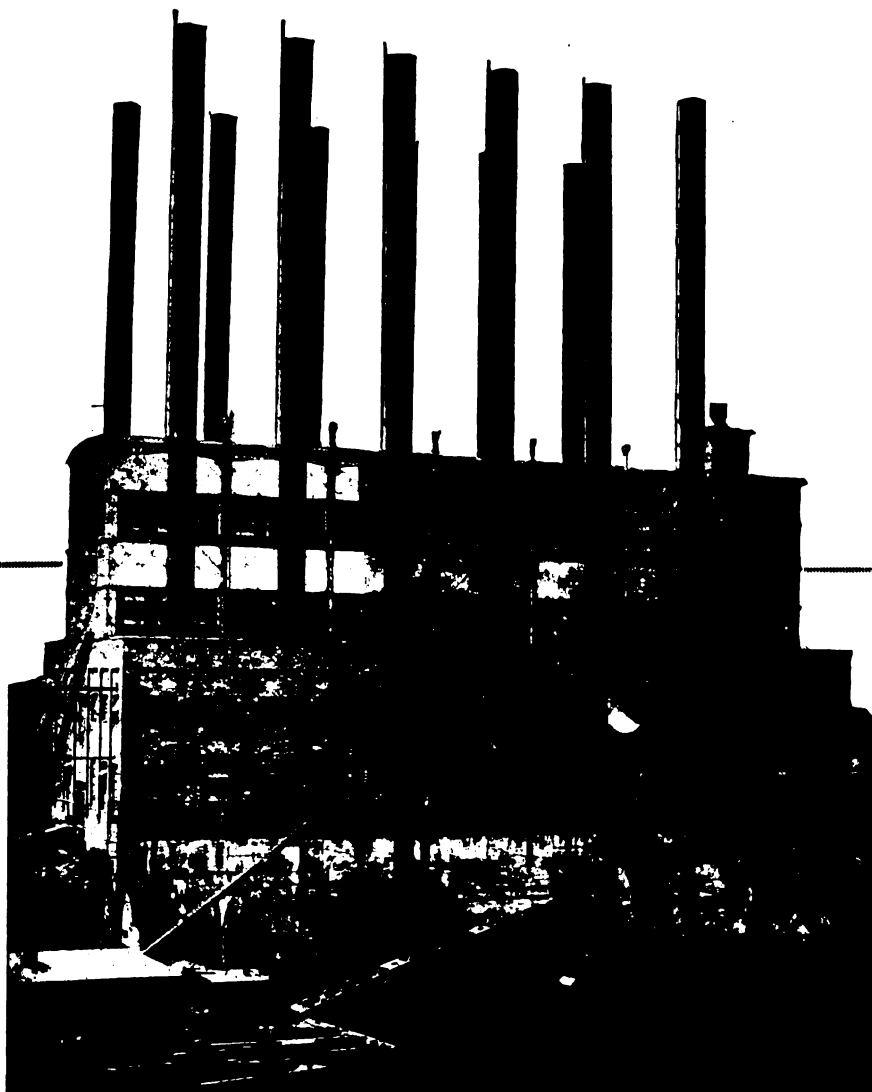
Power Department

Recent Developments in Steel Works Power Plants
By **W. N. FLANAGAN**

Actual Performance of Powdered Coal
By **CHAS. LONGENECKER**

Development of the Steam Turbine
By **ROBERT JUNE**

Modern Steam Generating Station
By **G. C. EMMONS**



Recent Developments in Steel Works Power Plants

In View of Scarcity and High Price of Coal and Labor a Review of Some of Steps That Have Been Taken by Steel Plants to Reduce the Consumption of Both Brings Forth Many Interesting Points.

By W. N. FLANAGAN,
Steam Engineer, Ohio Works.

DUE to the increasing use of turbines, occasioned by electrically driven mills and to engine improvements, very few boilers of lower working pressure than 250 lbs. are now being installed in steel plants. The new limit of 350 lbs. has not yet been reached in steel works, but will likely be used in the near future in new plants. The mark has already been reached by power companies as there are at least two plants installed with 350 lb. boilers. The equipment has already passed the "special" stage, as manufacturers are ready to build boilers and turbines for 350 lbs., and several manufacturers have already developed and are building a line of 350 lb.-800 degree F. valves.

Most of the new installations are of large units, 1,000 hp or more, for several reasons; chief among which are less labor, less space, lower radiation loss and the fact that control apparatus, instruments and attention can be applied to a large boiler at a much lower cost per boiler hp than to a small one. The iron and steel industry led the power field last year due to the installation of the largest boilers in the world at the Ford blast furnaces.

The general tendency is to burn only one type of fuel under a given boiler: either gas, coal or coke breeze. However, installations are contemplated with both stokers and blast furnace gas under the same boilers, the stokers to operate when the gas supply is deficient; and in many cases coke oven gas is burned in connection with coke breeze. However, the gas is used mainly to help ignition and when in surplus. The Ladd boilers at the Ford blast furnaces are equipped to burn both gas and powdered coal.

A notable feature of the Ford boilers, which illustrates the tendency of the times, is the combustion chamber. From the ground to the steam nozzle is equivalent almost to a blast furnace in height, namely 85 feet. With modern settings the boilers are set high above the grates. Complete and smokeless combustion at high ratings and higher boiler efficiency result therefrom, also from the fact that the first pass tubes are cleaner due to less spattering of ash and clinker from the fire.

Waste Heat Boilers.

Boilers using waste heat from furnaces early acquired a bad reputation in many plants which, upon analysis, seems due in addition to improper selection of equipment, to poor installations; i. e. cramped, dark and inaccessible location, too light or too small fans, air leakage and poor auxiliary equipment. Some of the more modern installations have been very successful on account of the following points:

Proper location for room, access and repairs. Preferably grouping to insure attendance.

Proper selection of boiler and setting with a view to obtaining an air tight setting.

Coating of settings with plastic covering. On account of high draft in waste heat boilers, namely, boiler draft loss plus furnace draft, the amount of air leakage is far greater than on a separately fired boiler, unless settings are tight.

Selection of rugged fans and drives of ample capacity.

Fans can now be obtained that will not require inspection or overhauling any oftener than the source of waste heat. Installation of reliable accessories, such as feedwater regulators, in duplicate, thus reducing attendance and danger to the minimum.

Attention to cleaning and means for doing same.

Superheaters.

The same conditions which have increased the boiler pressures up to 250 lbs. and higher have caused superheaters to be installed in practically every new installation. In addition superheat is being used successfully on old engines provided it is kept fairly uniform and not over 100 degrees F. Superheaters are installed in many coke and benzol plant boilers, not only for economy, but also to produce high temperature steam for distillation processes.

Economizers.

While previous to last year many economizers were installed, few new installations have appeared. Several plants have been built without, in spite of the consensus of opinion that economizers should be installed. This seems to be the period of watchful waiting for developments in the steel tube economizer.

Deaerating apparatus has been developed which practically assures the success of the steel tube economizers, as it protects the economizer against internal corrosion and external corrosion is guarded against by supplying feedwater above the dew point of the waste gases, which is seldom higher than 120 degrees F.

Stokers.

Several new makes of stokers have appeared on the market recently and at least three of these have been selected for steel works installations.

For burning coal underfeed stokers have been installed in most cases with a marked tendency to the extra long type. One of the most noticeable features is the use of air cooled dead plates, windboxes or side tuyeres, or special brick with holes for air admission along the side walls, all of which are designed to protect the side walls and avoid the use of steam jets.

For burning coke breeze the accepted stoker seems to be the forced draft traveling-grate type. The

mechanical difficulties of this type stoker appear to have been solved, the greatest source of trouble being arches, other brickwork and ignition. Considerable experimenting has been done in plants equipped with traveling-grate stokers on arches when burning coke breeze. Various types of flat and spring arches at various heights and angles have been tried and ignition problems solved by the proper arrangement of the arch so that the radiant heat from the fuel bed is absorbed by the arch and radiated or reflected to the green fuel. Ignition is assisted considerably by proper application of the forced draft under the front of the stoker so as not to pass too much cold air through the fuel before it is properly ignited. One make of stoker has means provided to obtain a suction under this front section and draw hot gases down through the green fuel. This is similar in effect to

fully all the coke breeze obtained from their furnaces, but have considerably reduced stock piles of breeze accumulated while coal was plentiful.

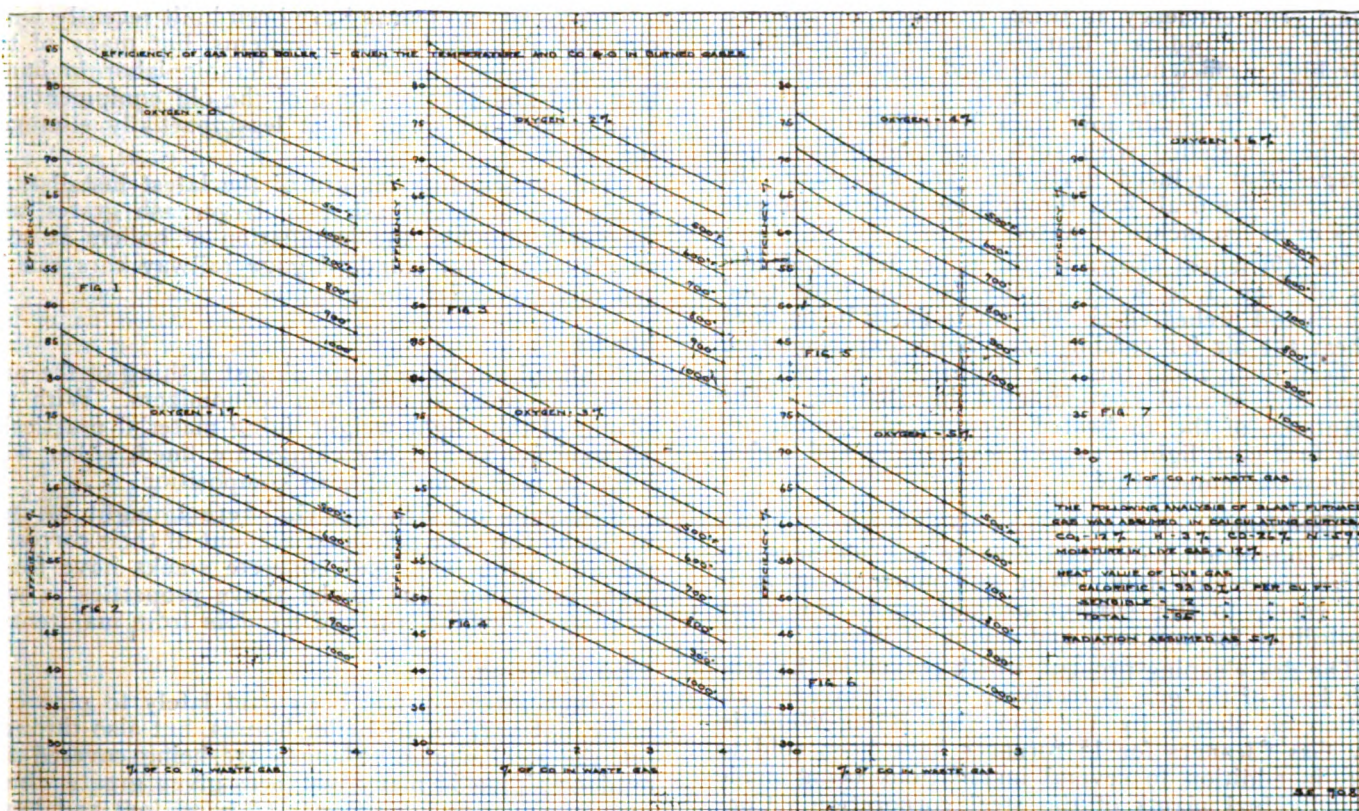
Powdered Coal.

Powdered coal has been used quite successfully in metallurgical furnaces in steel plants, but comparatively little has been done to use it under boilers on a large scale except at the Ford River Rouge Plant.

For small installations stokers are undoubtedly more economical, but in large installations, as evidenced by the decision of the Ford engineers and some of the central stations, powdered coal can be made to pay better than stokers due to lower excess air, combustible in ash and standby losses.

Gas Burners.

Increasing attention is being paid to burners. The



the practice of carrying a pressure in the combustion chamber on coke breeze stokers, which practice, however is very detrimental to the brickwork. Many boilers are equipped with burners for coke oven gas so located as to produce a flame under the ignition arch. These are used to help ignition of very poor or wet coke breeze.

In plants which have no coke ovens there is coke breeze screened out at the blast furnaces from which 200 to 300 bhp per furnace is obtainable. Many plants, rather than install separate stokers are burning coke breeze on underfeed stokers or on hand fired grates with forced draft. It has been burned successfully on underfeed stokers either straight or mixed with coal. When burned without coal, coke breeze requires about three times the labor necessary for straight coal. However, mixtures of 25 per cent coke and 75 per cent coal are being burned with practically the same effort required for coal. During the past year many plants have not only consumed success-

ordinary burner found in many plants requires constant adjusting to proportion the air supply with varying gas pressures. Even if this is watched closely the above burners do not attain thorough enough mixing to insure combustion before the gases strike the tubes, unless the combustion chamber is abnormally large with consequent radiation loss. The unburned gases are chilled off thus, either burning into the last pass causing high stack temperature, or causing high CO in the stack gases with accompanying loss, or both. Recent burner development is along either two lines; first, with an aspirating type of burner which uses the gas velocity to draw in correct air for combustion at all ratings, or second, an air fan combined with a regulator to automatically supply air to the burner independently of draft and in correct proportion to the gas flow. In both cases the air and gas parts are subdivided giving alternate thin layers of air and gas. The second type burner is fairly complicated and expensive for numerous small boilers, but

is well worth the expense for large units. The aspirating burner is well adapted to small units as it can be installed for very little more than a common "gas feeder", requires no expert attention and has no maintenance. For example a 300 hp boiler at about 120 per cent rating equipped with goose neck burners while running with 6 per cent oxygen showed 2 per cent CO in stack and a stack temperature of over 800 degrees F., or a boiler efficiency of approximately 46 per cent. Equipped with aspirating burners the same boiler averaged day after day 23 per cent CO₂, no CO and 600 degrees F. stack temperature giving a boiler efficiency of 73 per cent.

The curves in Figs. 1 to 7 show boiler efficiencies when burning blast furnace gas with various flue gas analyses and stack temperatures. They also show the efficiencies possible by good burners, long gas passages in boilers and by economizers or air heaters. 70 per cent efficiency is being obtained by modern burners under ordinary installations of small boilers, while higher efficiencies are obtained with larger units and boilers with longer gas travel.

In order to obtain low stack temperatures boilers have been installed with such long and broken gas passages that induced draft fans are necessary. In some cases the draft loss through the boilers amounts to six or seven inches of water.

The efficiencies shown at the upper left hand corners of Figs. 1 to 4 are readily possible with good burners and preheated air, the waste gases being used to heat the air for combustion. Some experimenting has been done along this line resulting in at least one actual and several contemplated installations. The advantages of the air heated over an economizer are lower first cost, lighter weight, less repairs and higher combustion temperature.

Gas Cleaners.

In connection with blast furnace gas, cleaners are a very important item. More and more attention is paid yearly to this subject on account of the great possibilities for economy and saving of labor.

The dry cleaning process, which preserves the sensible heat of the gas, is receiving almost universal attention as shown by the fact that Kling-Weidlein Dry Gas Cleaners for 15 furnaces have been sold to date, in addition to several installations being made by individual plants of the steel corporation. Considerable experimenting has been done with whirlers and electrical methods of precipitation resulting in a few installations. Since the sensible heat of the gas is from 6 to 14 per cent of the total heat a good dry cleaner is a valuable fuel saving adjunct in addition to saving power and labor. For instance the Kling-Weidlein Cleaner requires only two to three hp for operation as against up to 100 hp for an efficient wet washer.

In many plants equipped with wet washers capable of cleaning gas to not less than 1.0 grain per cubic foot, raw gas is being burned under the boilers. This method saves the sensible heat of the gas, and while the dust causes a little more labor in cleaning settings and blowing tubes than the half washed gas and considerably more than properly cleaned gas, the method has been found to be more efficient than using partly washed gas.

Control Apparatus.

On account of the fluctuating load of a steel works, particularly where blast furnace gas furnishes part of

the fuel, a good combustion control system is almost essential. There are several systems on the market now and practically every system is in use in at least one steel works boiler plant, which shows that this feature is clearly recognized by steel works engineers. Automatic control is far more necessary in a steel works boiler plant, where the firemen are frequently common labor, than in a central station where the boiler attendants are paid wages equalling those of other skilled trades.

However, the central stations are gradually turning to automatic control, since a good control equipment can follow load fluctuations and proportion fuel, air and draft much more closely than hand operation. It also leaves the fireman free to devote his entire time to keeping the fires in good condition.

Coal and Ash Handling.

Practically no plants have been built recently without coal and ash handling systems, but many of the old installations involve considerable labor in handling coal and ashes. Some of the old equipment has been remodeled so as to at least partially eliminate the labor.

The outstanding feature of the latest installations is the use of larger ash pits, larger ash grates, and wherever possible, the installation of boilers at such an elevation that standard gage railway cars can be run directly under the ash pits.

Stacks.

Unlined steel stacks are almost a thing of the past except as short stacks from economizers. With the advent of thin, light weight lining material practically all steel stacks and breachings are lined, either with brick or with some asbestos composition.

Concrete and brick stacks were brought to steel works by the coke plants on account of their corrosion resisting properties, and concrete stacks have found favor for boilers due to the above properties as well as reasonable first cost and freedom from maintenance.

Pipe Covering.

Much attention has been paid lately to pipe covering, not only in the boiler houses, but also throughout the steel works. Flanges are being covered and outdoor piping in many instances given greater thickness of covering on account of wind loss and lower temperatures. In addition to piping and fittings all exposed surfaces such as boiler drum heads, steam traps, etc., are now found covered.

While 85 per cent magnesia has been the standard covering for years the manufacturers are devoting attention to producing more rugged covering, to the protection of covering used outdoors and in wet places, and to covering for high temperature piping.

Prime Movers.

Due to the increasing number of electric drives in the steel plants larger turbine units are being installed than formerly. While no exceedingly large units have been installed in steel plants, there are many installations between 10,000 and 20,000 kw. sizes which give good economy. Units up to 45,000 kw in a single casing and up to 60,000 kw in three unit machines have been installed in central stations.

A large reversing engine was built this year designed for 225 lbs. per square inch working pressure and 125 degrees F. superheat. The most noticeable

feature besides the high pressure and superheat is the simplicity and accessibility.

The twin tandem compound engine with single lever control seems to be standard for steam reversing drives in this country, although in Europe many triple tandem engines have been built.

For continuous running mills the uniflow engine is rapidly coming into prominence. The early installations have shown great reliability, while the economy of the uniflow over wide load ranges is almost an accepted fact. In this country last year there were three new installations for driving rolling mills, two of which were duplex engines, also several power installations. There are now being built two 40" x 48" duplex uniflow engines for hot mill drives. These engines are to develop an average of 2,500 hp each, and a maximum of 5,000 hp each. The engines will be geared to the roll trains.

Air Compressors.

While of a somewhat minor importance the air compressing and distributing systems in many plants have been more carefully studied resulting in many cases in the installation of large central air compressors in the power house and the elimination of small isolated compressors. This results in better attention with less labor, as the compressors are under attendance of the power house employees, greater reliability and much better economy. The compressors themselves are not only more efficient, but steam lines to the isolated compressors with their accompanying

radiation losses are replaced by air lines with no heat loss.

In connection with the central compressors, after-coolers are installed to prevent freezing of condensation in the exposed air lines. A few noteworthy installations of the air cooled type have been made and are operating successfully.

Hydraulic Pumps.

While the general tendency is to use motors instead of hydraulic equipment many plants on account of existing installations and its positiveness and simplicity still cling to it. As with the air compressors the tendency is to centralize the pumps and obtain the benefit of better attention and greater economy. The economy is also carried throughout the system by better attention to operating valves and packing, better pump valves, use of clean water, which tends to eliminate cutting, elimination of friction and proportioning of cylinders to the load thus reducing the quantity of water necessary.

Several filters have been installed for water to hydraulic systems, and many plants use water that has been treated in the water softening system.

All of the accessories such as feed pumps, pump governors, feed water regulators, soot blowers, fans, instruments found in any power plant are now to be seen in modern steel works power houses showing that the power problem is being more seriously and scientifically considered than formerly and is being gradually brought to the most up to date solution.

Actual Performance of Powdered Coal

A General Description of the Burning of Powdered Coal Under Boilers—Actual Results Obtained Through a Number of Recent Tests—Increased Interest Shown in This Method of Burning Coal.

By CHAS. LONGENECKER.

TWO notable epochs work the history of the development of boiler furnaces. The first dates from the introduction of the stoker as a means of supplying the furnace with fuel; the second began when powdered coal was first burned under boilers. The early history in the perfecting of these two methods bear a striking analogy. Both had to overcome numerous and in many instances similar obstacles which called for the highest class of engineering skill in order that satisfactory results might be obtained. This analogy could be carried further and would show that in both cases it was necessary, not only to surmount all physical difficulties, but also to contend against a precedent which in many instances was the most discouraging. To complete the analogy it can be regarded that both powdered coal and stoker firing successfully passed through the experimental stages and are now established on substantial basis.

These naturally raise the question, which method will give the most economical and satisfactory results? To answer this question intelligently, it is necessary to know the results achieved by both methods. The merits of the stoker and the results obtained where it has been employed have been very fully and frequently set forth. The aim of this article is to present

some information based mainly on tests where boilers were heated by coal introduced into the combustion chamber in the powdered state.

Before entering upon a discussion of the actual performance of these boilers, there are some general facts which may aid in presenting the subject more clearly.

There probably is no severer test of any fuel, or method of burning a fuel, than demanded by the generation of steam in boilers. The first demand is that capacity be obtained and this may be placed at from "rated capacity" to 300 to 400 per cent higher. In many cases the load, and output, is variable fluctuating from normal to "peak" of possibly 400 per cent in a period measured by minutes. Such operation makes imperative immediate response in the quantity of heat generated. With this flexibility of control, high efficiency is also expected. In contrast to the plant with such variable conditions is the plant where the load is constant over a period of time. Here uninterrupted and steady operation of the furnace is desired. Other features requisite are the ability to raise steam rapidly from a "banked furnace" condition and the ability to return to this condition when the load is removed. In addition to meeting the above

requirements the system must operate with economy and be mechanically efficient. The limiting factor in obtaining a high capacity will be the size of the combustion chamber which in turn limits the amount of coal that can be burned efficiently. In a majority of the early installations, the combustion space was too small and it was impossible to secure a high rate of evaporation. The troubles arising from such restricted volume are cumulative. Besides low evaporation most of the other ailments which arose were traceable to this same faulty furnace design. With increased volume, secured principally by greater depth, and a change in the burner from a horizontal to a vertical position, a majority of the troubles disappeared.

Recently some very interesting tests have been made on large boilers and under the most reliable supervision conforming strictly to the regulations governing boiler tests as issued by the A. M. S. E. These tests will not be presented as a whole but the reports will be excerpted and the most important features discussed.

One series of tests was made on 520 hp Babcock & Wilcox boilers fitted with economizers. The combustion chamber had a volume that "the ratio of water heating surface of boiler to volume of combustion space" was 1 to .384 and with economizer this ratio was 1 to .194. Another test shows this ratio to be 1 to 0.359. In none of these tests was there any endeavor toward securing high capacity. It was the desire to see how the boilers were performing at normal operation. Three tests show the "rated capacity developed", 130.1, 149.7, and 149.7 per cent. This illustrates the capacity of boilers at normal operation with "ratio of water heating surface of boiler to volume of combustion space", as previously given.

Assuring a coal consumption of $1\frac{1}{2}$ pounds per hour per cubic foot of combustion space in a chamber having a volume of 2,000 cubic feet, 3,000 pounds of coal would be consumed per hour. One bhp can be generated on a coal consumption of 3.31 pounds (average of four tests) so that a 5,000 hp boiler with a combustion chamber of the size given would develop 907 hp. This would give a rating of 182 per cent. This rating can be reached with ease.

The efficiency in the three tests cited were as follows: 77.20, 79.87, 82.32 per cent without economizers. With economizers the efficiencies were respectively 83.33, 87.03, and 85.85 per cent.

There is no method of feeding coal which responds as readily and as quickly to fluctuating demands as when fed in a powdered state. In one large plant, in which some of the boilers are equipped with stokers and others with powdered coal, the fluctuations in load are handled entirely by those boilers burning powdered coal. This feature is one of the strongest in favor of this method of burning coal. When the fire is "banked" (if such a condition may be applied to a furnace fired with powdered coal) there is no loss of fuel and steam is maintained with small loss of pressure by the heat radiated from the setting. This saving in fuel would amount to about 1 per cent.

Another interesting feature in connection with this method of feeding boilers is that it is found more economical to run with CO, not excessively high. Successful plants today do not aim to secure a CO, content above 10 to 13 per cent. This is a decided departure from accepted practice, especially as pertaining to stoker firing. The reason for not desiring such a high content is because cutting of brickwork is more

rapid and the evaporation is lower. The evaporation is reduced due to the increase in velocity of the gases and a consequent lessening of heat transfer. What loss there is from heat carried away in the waste gases is more than compensated for by increased evaporation and longer furnace life. The percentage of CO₂ is an index to the quantity of excess air and naturally it will be supposed that this quantity may be high. Tests show from 30 to 80 per cent normally. This percentage of excess air is not necessary for the purpose of obtaining proper combustion as this can be obtained with a very much less per cent. The only reason excess air is required, is to moderate the temperature, which, due to the efficiency of combustion, will otherwise be too high. The temperature in the bottom of the furnace should as far as tests indicate, be about 2,200 degrees F. The temperature of the gases leaving the economizer in the tests cited were 248.3 F., 252 F. and 252.5 degrees F.

The equivalent evaporation per pound of coal as fired of boiler and economizer is: 11.27, 10.63 and 10.18 pounds, and "based on temperature of water entering boiler" 10.38, 9.76 and 9.84 pounds. The coal burned in the above tests had a calorific value of 13,147, 12,610 and 11,610 btu with an ash content of 10.83, 17.52 and 19.50 per cent. Degrees of superheat, 112 F., 117.7 F. and 114.9 degrees F. The heat balances for the three tests are as follows:

Heat Balance Based on One Pound of Combustible.

Heat absorbed by the boiler.....	12,304.9	82.77
Loss due to evaporation of moisture in coal	9.831	.066
Loss due to heat carried away by steam formed by the burning of hydrogen.....	581.39	3.908
Loss due to heat carried away in the dry flue gases	950.5	6.39
Loss due to carbon monoxide.....	175.7	1.18
Loss due to combustible in ash and refuse..	00	0
Loss due to heating moisture in air.....	42.23	.283
Loss due to unconsumed hydrogen and hydro-carbon, unaccounted for and radiation	710.4	4.77

Total calorific value of one pound of combustible

14,875

Heat Balance Based on One Pound of Combustible.

	Btu	Per cent
Heat absorbed by the boiler.....	126.54	84.28
Loss due to evaporation of moisture in coal	12.654	.084
Loss due to heat carried away by steam formed by the burning of hydrogen.....	555.6	3.7
Loss due to heat carried away in dry flue gases	990	6.50
Loss due to carbon monoxide.....	143	.952
Loss due to combustible in ash and refuse..	0	
Loss due to heating moisture in air.....	45.1	.30
Loss due to unconsumed hydrogen and hydro-carbons, unaccounted for and radiation	613.0	4.08

Total calorific value of one pound of combustible

15,013

99.98

Heat Balance Based on One Pound of Combustible.

	Btu	Per cent
Heat absorbed by the boiler.....	12,382	85.85
Loss due to evaporation of moisture in coal	11.6	.078
Loss due to heat carried away by steam formed by the burning of hydrogen.....	582.3	3.91
Loss due to heat carried away in dry flue gases	1,011.5	6.79
Loss due to carbon monoxide.....	86.98	.555
Loss due to combustible in ash and refuse..	44	.295
Loss due to heating moisture in air.....	44	.295
Loss due to unconsumed hydrogen and radiation	303.62	2.041

Total calorific value of one pound of combustible

14,422

99.5

All the data heretofore presented was derived from boilers fired with bituminous coal. Similar tests have been run on anthracite coal. The results are equally favorable. There is no question but that anthracite coal can be burned as efficiently as bituminous, but its preparation is more difficult. It is harder to pulverize and entails greater wear on the machinery. As soon as this difficulty is overcome there will be a vast field open and that it will shortly be overcome is practically assured.

Results from tests on anthracite show:

Efficiency (furnace and economizer).....	78.5 %
Percentage of rated capacity developed.....	140.9 %
Temperature of steam	327.4 °F
Temperature bottom of combustion chamber.....	2195° F.
Equivalent evaporation per lb. of coal fired.....	9.78
Calorific value of lb. dry coal (calorimeter) Btu.....	12,484
Ash in coal	11.48%
Volatile matter	6.41%

No combustible was found in either the ash of the bituminous or anthracite coals. The foregoing data is given to show what can be expected in a plant operating under normal conditions where the equipment is not run at a maximum. Too frequently tests on boilers are not representative but show only results obtained under stressed conditions. Probably the most prevalent criticism heard today against powdered coal firing is in regard to the ash passing out of the stack. This has been very much exaggerated. In

a recently conducted test lasting for a period of several days no precipitation of ash could be found.

A retrospective view of the year shows an increasing appreciation of the advantages of powdered coal as a fuel for boilers. This is evidenced by the number of additional boiler plants installing equipment and the growing interest manifested by engineers and manufacturers. America is not alone in this displayed appreciation, as Japan, France, Belgium and England are keeping fully in touch with the progress made. Evidence is not at hand to show the precise number of boilers equipped in 1920 but the number is far greater than in the previous year.

Improvements in the perfecting of boiler operation will henceforth be confined largely to furnace design. It is in this direction that betterment has been secured in the past. The aim as expressed in the language of the engineer must be to maintain a better capacity—efficiency curve with less drop after arriving at “rated capacity.” The results thus far achieved certainly lend encouragement to the accomplishment of this desirable end. There is undoubtedly much room for improvement in perfecting the art of burning coal in any device. Efficiencies in practically all types of furnaces are low whatever the fuel. To raise this efficiency there must be adherence to certain basic laws. A study of these laws leave little doubt but that the burning of coal in the form of a powder is in accord with the conditions imposed.

Development of the Steam Turbine

This Development Has Taken Place Not Only With Respect to the Design of Turbines, but in Particular With Respect to the Very Great Increase in Their Application to Different Services.

By ROBERT JUNE.

THE past decade has witnessed a remarkable development of the steam turbine. This development has taken place not only with respect to the design of turbines, but in particular with respect to the very great increase in their application to different services.

Among the classes of work for which steam turbines are now being utilized, in addition to the driving of alternating current generators, are the propulsion of pumps, blowers, turbo-compressors and marine propellers. By means of gearing they are used to furnish power for reciprocating air compressors, rolling mill drives and other classes of slow speed machinery. At every point the steam turbine has found favor on account of its low first cost, low maintenance cost, small floor space requirements, and low cost of attendance. It is, indeed, making appreciable progress in relegating the reciprocating steam engine to a secondary and minor position. Although the reciprocating engine will be an important factor in power plant work for sometime to come, its field is being rapidly narrowed.

The Principle of the Steam Turbine.

Under given pressure and temperature conditions a pound of steam occupies a known volume and contains a definite amount of heat energy. Now, if one pound of steam is permitted to expand to a lower pressure without receiving additional heat or giving

up heat to surrounding bodies, it is capable of doing a certain amount of work which will be the same whether the expansion takes place in the cylinder of a reciprocating steam engine, a rotary piston engine, or the nozzles and blades of a steam turbine.

The process of the steam in the turbine differs from that in the reciprocating engine in that the flow of steam is continuous instead of intermittent. The steam turbine is a continuous mechanism, whereas, the reciprocating engine may be termed a ratchet mechanism. The reciprocating engine is designed to operate by the direct pressure of the steam, while the turbine is designed to work by changing the direction of motion of the flowing steam. The turbine is thus, in fact, a velocity motor and the steam engine a pressure motor.

The kinetic energy of fluid in motion is the source of power in the steam turbine. Let a fluid in motion impinge on moving vanes change the direction of flow and reduce the velocity of the fluid, and the energy of the fluid will be converted into mechanical work and become available through the shaft on which the moving vanes are placed.

The successful steam turbine must embody the following characteristics:

1. The highest possible percentage of the heat energy of the steam must be converted into kinetic energy.
2. Provision must be made to utilize this kinetic energy in the most efficient manner by proper design of the rotor,

nozzles and guide passages of the turbine.

3. Design and construction of casing, rotor, and blades must be such that they will hold their form and remain tight against leakage under heat and centrifugal strains.

4. The velocity of all moving parts must be within safe limits and the apparatus must run at the proper speed at point of delivery of power.

Advantages of the Steam Turbine.

Among the principal advantages of the steam turbine are:

1. **First Cost**—As a general proposition steam turbines are lower in first cost than reciprocating engines of equivalent rated capacity. In a general discussion of this character, little would be gained by reciting specific examples to prove this proposition. This is true because of the various uses to which turbines are applied, and on account of the extreme variations in design. However, it is safe to say that for

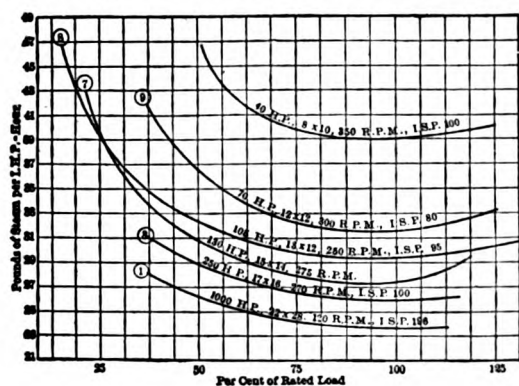


Fig. 1.

general service conditions it will be found that the turbine is lower in first cost than the steam engine in four cases out of five. The way to determine the matter in a specific case is to get actual figures from builders of both reciprocating engines and of turbines.

2. **Maintenance and Attendance**—The reciprocating engine contains a much smaller number of parts than the turbine, but on the other hand, the turbine possesses a very great advantage over the other type of prime mover, because of fewer moving parts and rubbing surfaces. The only contact between the moving and stationary parts is in the main bearings, and the problem of lubrication is, therefore, a simple one. Furthermore, the absence of pistons, stuffing boxes, dash pots, and friction surfaces, reduces the cost of maintenance and attendance to a minimum and limits the possibilities of leaking.

3. **Economy of Space and Foundation**—Reciprocating engines require much greater floor space than do steam turbines. As compared to a Corliss compound engine, a turbine of equivalent size will only take up from one-third to one-half the space. With straight line, non-condensing high speed engines the comparative economy in space is much less marked. However, even in such cases the average space occupied by the turbine is from 20 to 50 per cent less than that of the engine.

A most important feature of the steam turbine is that it is very much lighter in weight than the reciprocating engine. In the case of central stations, engines and generators may weigh as much as eight times more than turbine installations of equal capacity. Even in smaller installations, the turbine is very much lighter than the engine, and also because of a total absence of vibration, requires a relatively light

foundation. In many cases turbine foundations consist simply of steel beams with concrete arches so that the basement underneath may be used for the condenser and other apparatus instead of being devoted to the massive foundation required for reciprocating engines.

4. **Absence of Oil in Condensed Steam**—Requiring as the turbine does no internal lubrication, there is no opportunity for oil to come in contact with the steam. Consequently, all steam from the surface condensers can be used for boiler feeding purposes without purification. This continued use of condensate effects a large saving in cost of feed water and in expense for maintenance and initial cleaning of boilers. Furthermore, the amount of entrained air is reduced to a minimum, and, consequently, the work of air pumps is lessened.

5. **Regulation**—It is much easier to regulate the speed of the turbine within close limits than it is a reciprocating engine. With the latter, moreover, a

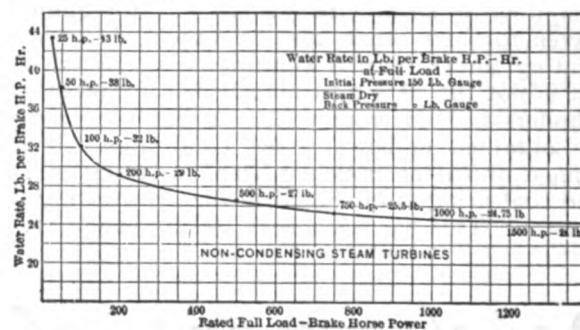


Fig. 2.

heavy flywheel is required to keep the instantaneous angular fluctuation within safe limits. Even with a constant load there are variations of velocity during each revolution of the reciprocating engine, while with the steam turbine the speed is practically constant. A number of published tests of Parsons and Curtiss turbines show an average fluctuation of not more than 2 per cent from no load to full load, and of not more than 3 per cent from no load to 100 per cent overload.

6. **Overload Capacity**—When we come to discuss overload in a prime mover, we are at some disadvantage, because of the fact that the rated load usually refers to the maximum economical load or the point of greatest efficiency. Both engines and turbines should, of course, be designed with the operating conditions clearly in mind so that they will operate at all times at high economy. The point of superiority of the turbine over the reciprocating engine lies in the fact that when occasion arises it can be operated with a greater percentage of load above the point of high efficiency than can the reciprocating engine.

Comparative Economy of Steam Engines and Turbines.

Any attempt at a specific comparison of the steam consumption per brake horse power of reciprocating engines and steam turbines is very unsatisfactory because of the wide range of operating conditions.

As a general proposition, the reciprocating engine is more economical in the use of steam for non-condensing service and the contrary is true for high pressure, high vacuum condensing service.

The general statement we have just made should be modified so far as it concerns condensing engines of the uniflow or poppet valve type as these engines, under favorable conditions, often show superior econ-

omy to the turbine for sizes up to 3,000 hp. The superiority of the uniflow and poppet valve engines over the ordinary slide valve type, lies in the fact that their construction is such that the steam is not brought into contact with cold surfaces to the same extent.

A comparison of the curves in Fig. 1 showing typical economies of high speed, single valve, non-condensing engines, and the curves in Fig. 2 showing the performance of non-condensing steam turbines, is somewhat in favor of the reciprocating engine, the difference decreasing as the size of the unit increases. When we come to make a similar comparison on the performance curves of compound, single valve, single cylinder, four valve and compound four valve, non-condensing reciprocating engines with those of steam turbines of the same size we find a marked increase in economy in favor of the reciprocating engine.

In order to give some definite idea of the steam consumption of the small turbine we include Table 1, which gives the manufacturer's guarantee on one of the best known makes:

Table 1—Performance of the Modern Steam Turbine at Rated Capacity.

(Manufacturer's Guarantee)						
Rated capacity hp	R.P.M.	Initial Pressure lb. Abs.	Back Pressure inches	Super heat deg. F.	Lb. steam per kw-hr*	Rankine cycle ratio
25	3600	165	At.	0	*43.0	*31.0
50	3600	165	At.	0	*38.0	*34.2
100	3600	165	At.	0	*32.0	*40.6
200	3600	165	At.	0	*29.0	*44.9
500	3600	165	At.	0	*27.0	*48.1
750	3600	165	At.	0	*25.5	*51.0
1,000	3600	165	At.	0	*24.75	*57.5
1,500	3600	165	At.	0	*24.0	*59.1

*Based on developed horsepower.

A very interesting combination plant which has frequently been used in this country consists of a high pressure engine exhausting into a low pressure condensing turbine. This arrangement is very hard to beat so far as economy is concerned.

It should be kept in mind, however, that there are a great many other factors beside high economy to take into account in deciding whether to purchase a turbine or a reciprocating engine. Every one of the factors mentioned earlier in our discussion under advantages of the steam turbine should be given consideration, and it is quite possible that they will be found to outweigh the advantage of high economy of the engine.

Influence of Superheat on Economy.

When plant conditions make it practicable to provide superheated steam for turbines without incurring more than a normal expenditure, it is desirable to do so. The gain in heat economy due to the use of superheat is theoretically the same for all types of prime movers. Actually, however, the rate of improvement varies considerably with the type of mechanism. In the reciprocating engine the gain is due mainly to the reduction of cylinder condensation, while in the turbine the improvement in economy is due primarily to the reduction in "windage" and other friction losses. The actual gain is, furthermore, very much greater than the theoretical gain. In the ideal frictionless high pressure condensing turbine an increase of 35 degrees in superheat would effect an increase of about 1 per cent in thermal efficiency. In the actual turbine we gain the 1 per cent increase in

thermal efficiency for each 6 to 14 degrees that we increase the superheat.

Superheat is of greater advantage with non-condensing turbines, and it is more marked with low pressure units than with high. In average practice the maximum temperature of the steam is approximately 500 degrees F., but in large central stations, temperatures of 600 degrees are not uncommon, and a number of recent installations have been designed for total temperatures of 700 degrees F. It should be remembered that the higher the initial temperature, the greater will be the investment cost and that a point will eventually be reached where the increased fixed charges will offset the gain in heat economy.

Innuence or heat Pressure.

In planning new installations it is extremely important to bear in mind the fact that the higher the steam pressure, the higher the economy. As a matter of fact, the increase in efficiency resulting from high boiler pressure is so marked that engineers are considering the possibility of employing pressures far above any now in use. We now have plants designed and in use where the boiler pressure is 350 pounds, and when it is possible to do so, working temperatures of 600 pounds per square inch will be employed.

There is no particular obstacle so far as the turbine is concerned in the use of such high pressures since it simply means the use of heavier parts for the high pressure end and a somewhat increased cost of construction. The difficulty lies with the boiler construction, and just when or how the problem will be solved, is still a matter of uncertainty.

Installations at the extremely high pressure just mentioned are and will be chiefly confined to the big central stations. However, it is well to keep the desirability of high pressure in mind in designing a new small plant. In other words, do not assume that pressure of 150 or 175 pounds is about right, without giving the matter further consideration. It may be proven just as easy, and far more economical, to use a working pressure of 250 or 275 pounds.

The Influence of High Vacuum.

High vacuum can be used to much greater advantage with the steam turbine than with the reciprocating engine. Even if it were practical to expand the steam to one pound absolute, the increased condensation in the reciprocating engine would probably hinder any gain due to expansion. A study of a number of tests of reciprocating engines shows but a slight improvement in overall plant economy due to increased vacuum beyond 26 inches.

A test of steam turbines shows a decrease in steam consumption of about 5 per cent for each inch of vacuum between 25 and 27 inches, 6 per cent for the gain between 27 and 28 inches, and 8 to 12 per cent for the gain between 28 and 29 inches. These values are approximate only, since the influence of vacuum on the steam consumption varies greatly with the type and size of turbine.

Here again we must remember that there is a critical point beyond which it is not economical to go in securing high vacuum. As the volume in steam increases very rapidly with the decrease in back pressure, the corresponding capacity and power required by the air and circulating pumps becomes proportionately larger. There is, consequently, a point where the improvement in steam economy fails to exceed the increased power demanded by the auxiliaries.

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Turbines vs. Engines in Units of Small Capacity.

The question of whether to use reciprocating engine or turbine is frequently a puzzling one to the owners of small plants. Some years ago Mr. K. S. Barstow presented a complete summary before the A. S. M. E. covering the applicability of engines and turbines for plants of less than 500 hp capacity. In studying this summary it is well to remember that considerable improvements in the turbine and its range of applicability have been made in the past several years, and that it is possible to use turbines in at least some of the applications assigned by Mr. Barstow to engines.

Applicability of Engines.

1. Non-condensing units, direct-connected or belted and used for driving:

Electric generators of all classes excepting exciter sets of small capacity, unless belted from the main engine. Centrifugal pumping machinery, operating under variable head and quality conditions and at relatively low heads, say up to 100 feet, depending on the capacity of the unit. Pumps and compressors for delivering water or gases in relatively small quantities and at relatively high pressures in the case of pumps at pressures above 100 pounds per square inch, and in the case of compressors at pressures from 1 pound per square inch and above.

Fans and blowers (including induced draft fans) for handling air in variable quantities and at relatively low pressures, say not over 5-inch water column.

Line shafts of mills, where the driven apparatus is closely grouped and the load factor is good.

All apparatus requiring reversal in direction of rotation, as in hoisting engines and engines for traction purposes.

2. Condensing units direct-connected or belted, for all the above purposes particularly where the condensing water supply is limited, and where the water must be recooled and recirculated.

Applicability of Turbines.

1. Direct-connected units, operating condensing. 60-cycle generators in all sizes, also 25-cycle generators above 1,000 kw capacity.

Direct-current generators in sizes up to 1,000-kw capacity, including exciter units of all sizes.

Centrifugal pumping machinery operating under substantially constant head and quantity conditions, and at moderately high head, say from 100 feet up, depending upon the size of the unit.

Fans and blowers for delivering air at pressures from 1½-inch water column to 30 pounds per square inch.

2. Direct-connected units, operating non-condensing for all the above purposes, in those cases wherein steam economy is not the prime factor or where the exhaust steam can be completely utilized, and, in the latter case, particularly where oil-free exhaust steam is desirable or essential.

3. Geared units, operating either condensing or non-condensing for all the above-mentioned applications, and in addition, many others which would otherwise fall in the category of the steam engine, on account of the relatively slow speed of the apparatus to be driven.

Next month we will discuss the individual types of turbines and deal with some of the problems incurred in their operation.

NAVY ARMOR PLATE PLANT.

The erection of the Naval Ordnance Plant at Charleston, W. Va., gives the Navy one of the most complete establishments in existence for the production of armor plate, gun forgings, and projectiles, and, furthermore, removes the possibility that in the future any monopoly can dictate to the Navy the price it shall pay for armor and shells," says Secretary Daniels, in his annual report of the activities of the Navy Department. Then he devotes a considerable section of the report to a survey of the history and progress of the Charleston plant.

"Established after years of discussion and consideration," declares the report, "this great plant exemplifies the policy that the government shall not be dependent upon private concerns to which profits must be the first consideration, but shall be able to manufacture in its own plants sufficient armor and munitions to supply a large part of its needs. The saving in production at cost and the determining by actual experience the prices the Navy should pay for such products when secured from private contractors would alone amply justify such an establishment, resulting in the saving of millions of dollars. But only less important is the ability to conduct constant experiments in improvement of armor and projectiles, and to retain such improvements for the exclusive use of our own government.

"The projectile plant, which was put in operation in 1919, is producing armor-piercing shells which have satisfactorily met every test. We have also succeeded in meeting the high specifications for air flasks, which the Navy has heretofore been able to obtain only from private manufacturers. This shows that our methods have proven entirely successful.

"The Naval Ordnance Plant is furnishing 6-in. 53-caliber gun forgings in increasing numbers to the naval gun factory at Washington, and it is expected that these two plants will take care of practically all the 6-in. gun construction for the Navy. The Charleston plant has also furnished a number of 16-in. breech-mechanism forgings for 16-in. guns.

The Armor Plate Plant.

"Very satisfactory progress has been made in the erection of equipment for the armor plate plant, and it is expected that the first heat of steel will be tapped during the present month. Twenty-five large heating furnaces for the manufacture of large-caliber gun forgings and armor plate, two 65-ton open hearth furnaces, and two 30-ton Heroult electrical furnaces for refining steel are in course of construction and approaching completion. A 14,000-ton press for forging and blending of armor plate and gun forgings is in course of manufacture. A boiler plant of 6500 hp, high-pressure pumping equipment, etc., has been obtained by transfer from the War Department. Construction work in the south unit, which comprises the armor and gun-forging plant, has been proceeding steadily, despite the acute labor shortage and the delay in the receipt of structural materials, due to the general unsettled industrial and railroad conditions.

Modern Steam Generating Station

Republic Iron and Steel Company, Youngstown, Ohio, Are Most Successfully Operating Their New Boiler House—Summary of the Performance of the Plant Is Given in Full.

By G. C. EMMONS,
Steam and Efficiency Engineer, Republic Iron & Steel Co.

A DESCRIPTION of the latest steam generating station of Republic Iron & Steel Co. is herein given, in the belief that it will be of interest and of possible assistance to the engineers and operators of other steel companies, confronted with a similar problem.

Before the latest boiler plant was built, the company had three boiler houses, one exclusively gas fired, served by their newest blast furnace, and the other two served respectively by one and three blast fur-

ing engines on the furnaces incapable of maintaining their revolutions; thus curtailing production of the entire system, and frequently rendering imperative the dropping of the load of a number of departments, in the steel mills.

Taking the above stated conditions and anticipated changes and expansions into consideration, the engineers of the company undertook to design, construct and operate a steam generating station that would be the most modern and efficient plant of its kind.

The station as planned will ultimately consist of twelve 1,130-hp power straight tube boilers, selected as being the most efficient type to operate under the existing conditions of load.

The first section of the plant consisting of four boilers has been in operation for approximately one year and one half.

The station is equipped with modern coal and ash handling machinery and each unit is provided with superheaters, soot blowers, automatic feed water regulators, fuel economizers, under feed stokers and forced and induced draft fans. The photograph of the outside of the station, Fig. 1, shows the arrangement of the coal and ash handling machinery. The general arrangement of the station is shown by Figs. 2 and 3.

Coal Handling.

Dropping the door of a hopper car, placed over the track unloading hopper, discharges its entire contents into the track unloading hopper. (Capacity 150 tons.)

By means of the coal gates at the bottom of the track unloading hopper, the rate at which the coal is fed to the transverse flight conveyor is regulated.

The transverse flight conveyor, rated 180 tons per hour, receives coal from track hopper, and delivers it into the crusher hopper. One side and top section of the conveyor casing is removed, and a control switch conveniently placed so that the conveyor can be stopped at this point to remove "tramp" iron or other foreign material carried with the coal.

The crusher, rated 180 tons per hour, employs two pairs of rolls, arranged one above the other so as to reduce the amount of fines produced. The crusher and transverse conveyor are driven by a 150-hp G. E. Slip ring type form M, 3-phase, 25-cycle, 220-volt motor, operating at 720 rpm and controlled by a drum starter.

Crushed coal is delivered by a bifurcated hopper, each leg of which is provided with an automatically opened and closed apron, to the hoisting buckets, each having a capacity of three tons. This hoisting mechanism is of special interest in that it is fully automatic, as will be seen by reference to Fig. 4, showing the hoist pit mechanism, the horns 1 on the descending bucket engage the shaft rollers 2 on the apron 3 and rotate the apron about the shaft 4 to the position shown, where it is held by the latch 5 until the coal

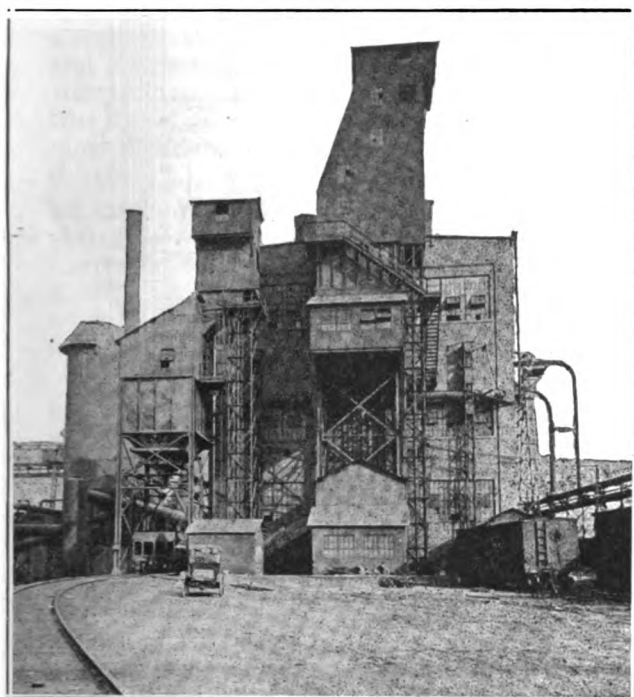


Fig. 1—Showing general arrangement of coal and ash handling machinery.

naces. The last mentioned boiler houses, designed primarily for burning blast furnace gas, had a number of boilers equipped with hand fired grates on which coal could be fired in emergencies. This arrangement, although not conducive to the economical burning of coal, sufficed for a time. Gradually, however, other departments were expanded, and their power demand thrown upon the principle electrical generating station, located in and supplied with steam by the blast furnace plant. This loading continued until the entire original steam surplus of the blast furnace plant was completely absorbed even with all five furnaces in blast. Under these conditions, whenever a furnace checked or stopped for any reason, the steam generation being insufficient for the demand, the steam pressure fell frequently to the point where the electrical frequency lagged sufficiently to impair the coke works and steel mill operations, and even rendering the blow-

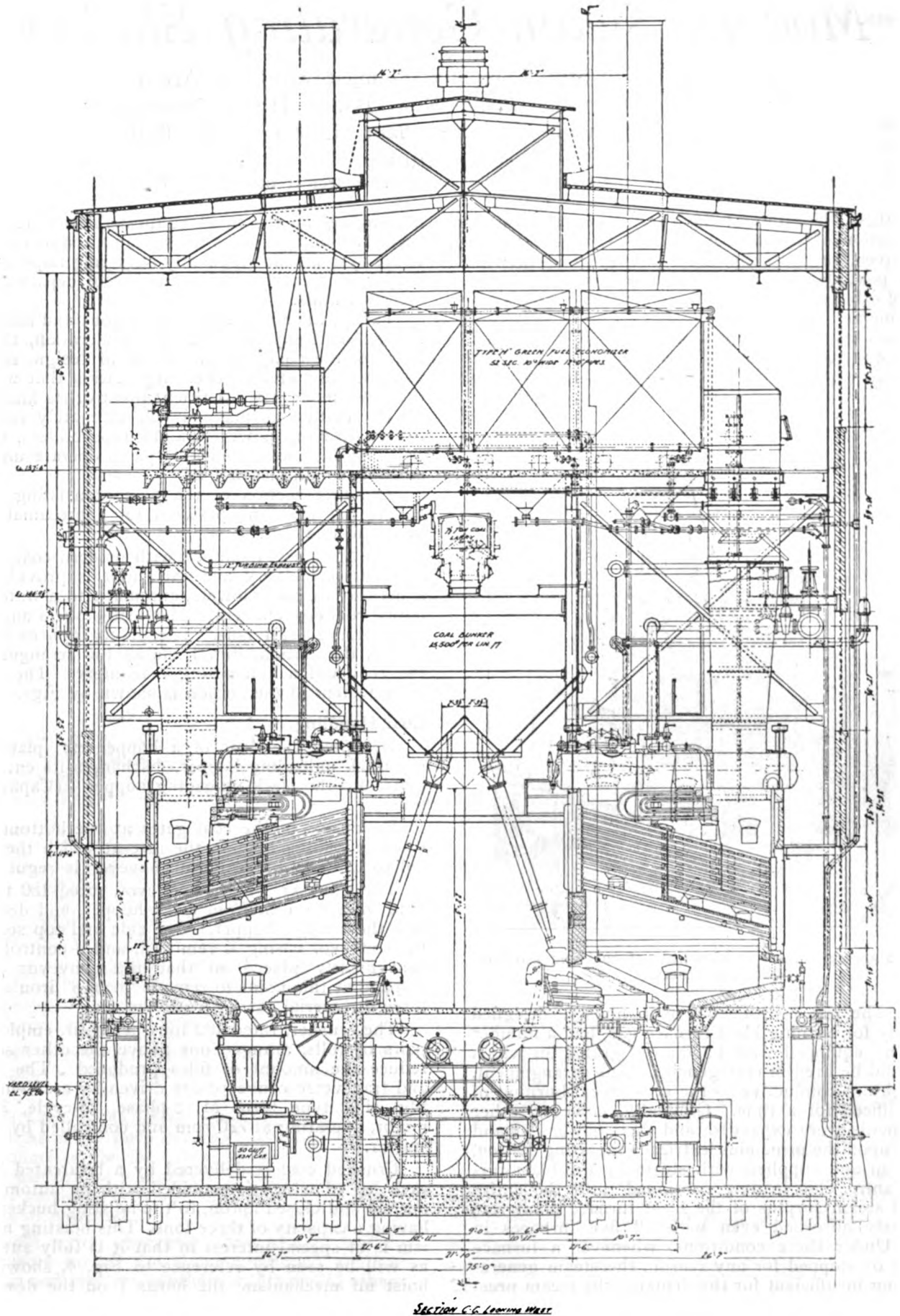


Fig. 2—Transverse section showing general arrangement of stokers, boilers, economizers and fans.

flowing from the chute 6 into the hoist bucket 7, increases the load on the beam on which it rests at 8 to the point where it overcomes and raises the counterweight 9, first releasing the bolt 5, allowing the counterweight 10 to close the apron, and then pulling in the hoist control switch 11, starting the hoist. The accelerating switches follow, bringing the hoist to full speed. A controller driven from the main hoist through bevel gears and screw slows the hoist down near the top of the hoist, and when it enters the trips shut off the power and sets the brake. The other cage having been lowered has opened the other apron and is receiving coal while resting on its weigh beam.

This system furnished by Bartlett & Snow Co., has been modified in two respects.

First— $\frac{5}{8}$ -inch instead of $1\frac{1}{4}$ -inch bolts are now employed to hold the crusher bearing caps so that the bolts instead of the more expensive bearing caps fail in the event that a large timber or similar substance beyond the strength of the crusher enters it.

Second—The hoist pit mechanism, shown in Fig. 4, was not entirely satisfactory, as the contacts of the Carpenter switch designated as point eleven of Fig. 4, and which control the hoisting contactor, were sometimes closed in practice before the bolt 5, shown in this figure, was released and the apron rotated to the clear position.

Whenever this occurred the hoist started and tore off the apron. This condition, however, has been obviated by inserting a second switch in series with the Carpenter switch, this second switch being closed by a wing on the counterweight arm of the apron only when the apron is in the clear or closed position. This is shown in photograph Fig. 5.

With this switch inserted in series with the original hoist contactor control switch, the hoist will not start unless the bucket has received its proper load and the apron has closed.

In actual operation, free running coal from a fully loaded hopper car is dumped, conveyed, crushed and delivered to the main storage bin in 20 minutes from the dropping of the car doors.

Coal Distribution.

The electrically operated coal larry shown in Fig. 6, is run and stopped under the 100-ton storage bin shown in Fig. 1, into which the hoist buckets discharge.

When the controller is thrown to run the larry out from under the storage bin, the coal gates are automatically opened and closed; thus loading the larry. As will be seen in Fig. 6, the coal larry is provided with two beams. With the lower beam rider at the extreme right end of the beam, the upper beam rider is moved until a balance is obtained. The larry is then run to the point where it is desired to discharge. The top hinged sides are then opened and the load discharged.

The larry then is closed up and without disturbing the upper beam rider, the lower rider is moved to the left until the beam again poises.

The lower beam rider is then clasped with the hand and a card carried by it is punched by a pin on the lower beam; thus recording the weight discharged by the larry.

The coal flows down the chutes from the bottom of the coal bunkers to the stoker hoppers.

Special Furnace and Boiler Arrangement.

Each of the B. & W. boilers contain 504 20-foot, 4-inch diameter tubes, arranged 14 high and 36 wide, giving a total heating surface of 11,296 square feet, or approximately 1,130 bhp.

Superheaters furnished by B. & W. have a superheating surface of 1,785 square feet and are guaranteed to give 110 degrees superheat at 225 pounds steam pressure.

The special furnace and boiler arrangement, designed by the company's engineers and employed in this plant is shown in Fig. 2. By referring to this

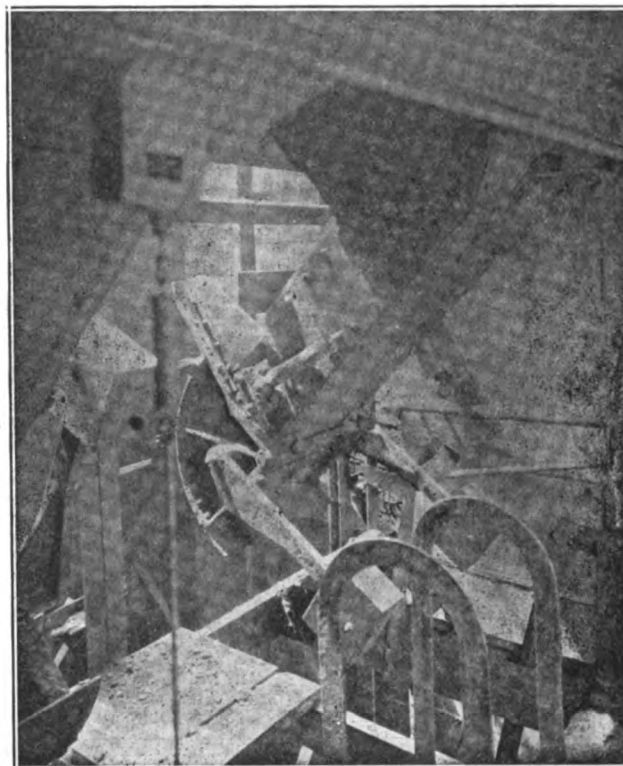


Fig. 5—Photograph of coal hoist pit mechanism showing series hoist contactor control switches installed.

figure, it will be noted that the boiler tube surface is arranged in two banks, the upper bank 12 tubes high, nested with the usual staggered tube arrangement. Below this main bank, there is a blank section two tubes in height, below which there is another bank two tubes in height and these instead of being of the usual staggered construction, are vertically above each other, being so placed in an effort to reduce slag accumulation on the upper row of tubes. The first baffle starts from the top of the first bank and extends up to the top of the main bank in the usual manner. The space between banks is employed for the horizontal baffle which extends from the first vertical baffle to the rear header, and is also available for soot accumulation. Advantage is taken of the free gas passage provided by the space between banks to carry down the second vertical baffle further than would be practical if the boiler was built in a single bank. This prevents short circuiting of the gases from the second to the third pass as it requires them to pass down to the bottom of the second pass before entering the third pass.

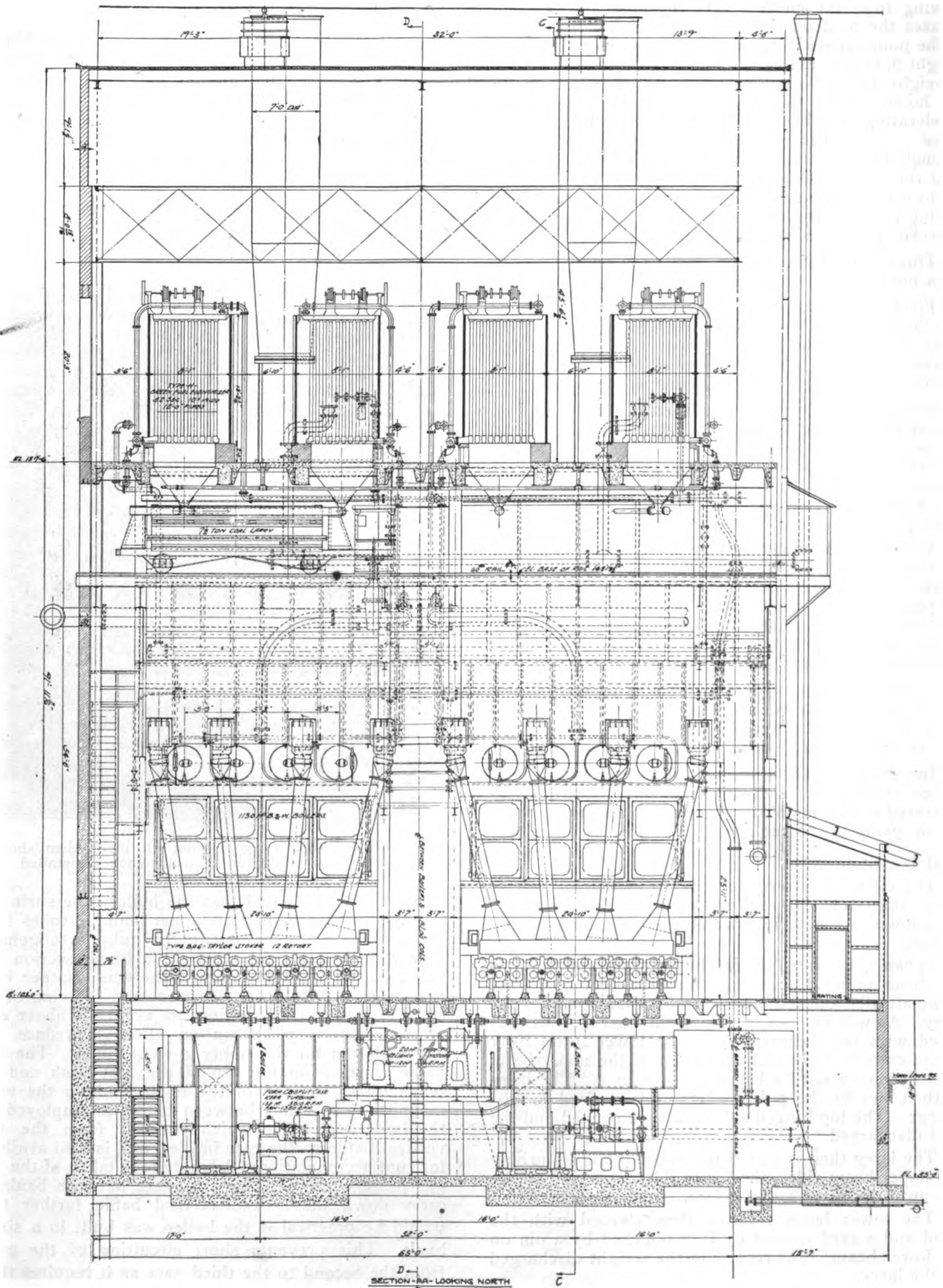


Fig. 3—Longitudinal section showing general arrangement of stokers, stoker drives and fans.

The arrangement of the boiler tube surface and baffling just described is essentially the same as that employed in a number of other modern stations, which were inspected prior to the designing of this boiler house and from those, these features were patterned. The important advantage of this arrangement of tube surface and baffles is that the lower tubes are exposed to the radiant heat energy throughout their entire furnace length. This, in comparison with the former construction, which employed a bridgewall, gives a greatly increased heat absorption.

At the time this plant was designed the latest practice was to arrange the stoker for firing under the low end. The important deviation from this practice was the firing under the high end and the employment of a slightly slanting floor under the rear end and the providing in the back wall of three inspection doors, which are used to good advantage in making observations to keep the fires in proper condition. The desired distance of the tubes above the stoker tuyeres is obtained with a setting and therefore a building five feet one inch less in height than if the boiler had been fired under the rear end.

The results of the special furnace and boiler arrangement, designed by the company's engineers, is seen in the departure from the usual practice, of the temperature at the top of the first pass and the temperature of gases leaving the boilers.

At 225 per cent of rating, the furnace temperature is 2,446 degrees F., and the temperature of the gases leaving the boiler is 545 degrees F. The gas temperature drop over the boiler is 1,901 degrees F.

The temperature in the first pass between the two banks of tubes is 1,340 degrees F., thus the temperature drop over the first two tubes is 1,106 degrees F., or 58 per cent of the total heat absorbed by the boiler.

The temperature at the top of the first pass is 727 degrees F., thus the temperature drop over the remaining 12 tubes in the first pass is 613 degrees F., or 32.2 per cent of the total heat absorbed by the boiler. It is thus seen that the temperature is dropped 1,719 degrees F. in the first pass, or that the first pass is absorbing approximately 90 per cent of the total heat absorbed by the boiler instead of the more usual 70 per cent.

Only $9\frac{1}{2}$ per cent of the total heat taken up by the boiler is absorbed by the superheater, second, and third passes combined.

Under continuous operating conditions, the boiler stack temperature at the same rating of 225 per cent, at which rating the test was made, varies from 562 degrees F. to 520 degrees F. The highest temperature corresponds closely to the usual temperature obtained with the 14-high boiler; whereas the lower temperature corresponds more nearly to a 16-high instead of a 14-high boiler.

These results are attributed principally to the increased rate of radiant heat absorbed, due to the fact that the contour of the incandescence surface of the fire more nearly parallels the absorbing tube surface than in a boiler furnace firing under the low end of the boiler, in which case, the radiant heat strikes the tube surface at an angle whether direct from the fire surface or by reflection from the opposite wall.

This special furnace and boiler arrangement, which gives a drop of 1,100 degrees over the first two tubes, and thus obtains a temperature of only 1,340 degrees F. between the two banks of the first pass of the boiler, suggested to the writer that in employing this furnace and boiler arrangement in the future, the superheater

should be placed between banks in the first pass instead of the usual location at the top of the first pass. This would result in much higher superheat, with the same size of superheater, placed in this location or give the same superheat with a smaller and therefore less expensive superheater.

This suggested location of the superheater between banks of the first pass of the boiler with this type of baffling has recently been incorporated in the design of a number of 1,900 hp units for one of the largest power companies in the country.

Fig. 7 is a view of the Republic furnace and boiler arrangement. No wall brickwork has been renewed in over one and one half year's operation.

Soot Blowers.

In an effort to definitely determine whether diagonal or direct blowing is most effective, two boilers are equipped with direct blowing soot blower nozzles with nine units on each side of the boiler and the other two boilers are equipped with diagonal blowing nozzles at all positions except at the front and back wall of the lower row and the superheater units which are direct blowing. All units with the exception of the units for the superheater have bearings on every other tube, and all are designed for properly cleaning the boiler with any steam pressure from 100 to 225 pounds gauge.

Stokers.

Each boiler is equipped with a special 12-retort, 22-tuyere, steam dump, Taylor Underfeed Stoker. Each stoker is divided into four sections of three retorts each; each section being provided with an individual power box and an individual and complete steam dump. Two steam dumps are operating from each side of the boiler. Each three retort section has its own separate wind box and its own separate and independent air connections and air ducts. This has been done so that if a section fails, the air can be shut off that section and the boiler continued in service without injury to the stoker for a far longer period than if a continuous wind box was employed. A number of important improvements have been made, which have greatly reduced the burnouts and therefore greatly reduced the maintenance and increased the continuity of service. The most important of these are:

1. The providing of integrally cast ram box cap and throat filler piece which conforms to the contour of the ram. This greatly reduced the number of ram box breakages.
2. Substituting old style single cast for cast en-block tuyeres. This reduced the sifting and wind box fires.
3. Attaching lower ram extension so as to move clinker down the fire and not permit it to stop and expose the lower tuyeres and grate surface.
4. Ventilating the coal plate and tuyere plates.
5. Reconstructing the grate operating link mechanism which materially facilitated the removal of the grate.
6. The designing and employing of heavier constructed dump plates.

Stoker Drive.

As shown by Figs. 2 and 3, the 20-hp, type E, Reliance, dc stoker-motors are mounted on a platform in the forced draft fan room. There is one provided for each boiler. Each has a speed variation of from 300 to 1,200 rpm, accomplished entirely by shunt field weakening; thus providing a highly efficient motor at all speeds, since no resistance is employed in series with the armature circuit for the low speed. As is usual practice, a line shaft is interposed between the motor shaft and the stoker speed shaft. Each motor

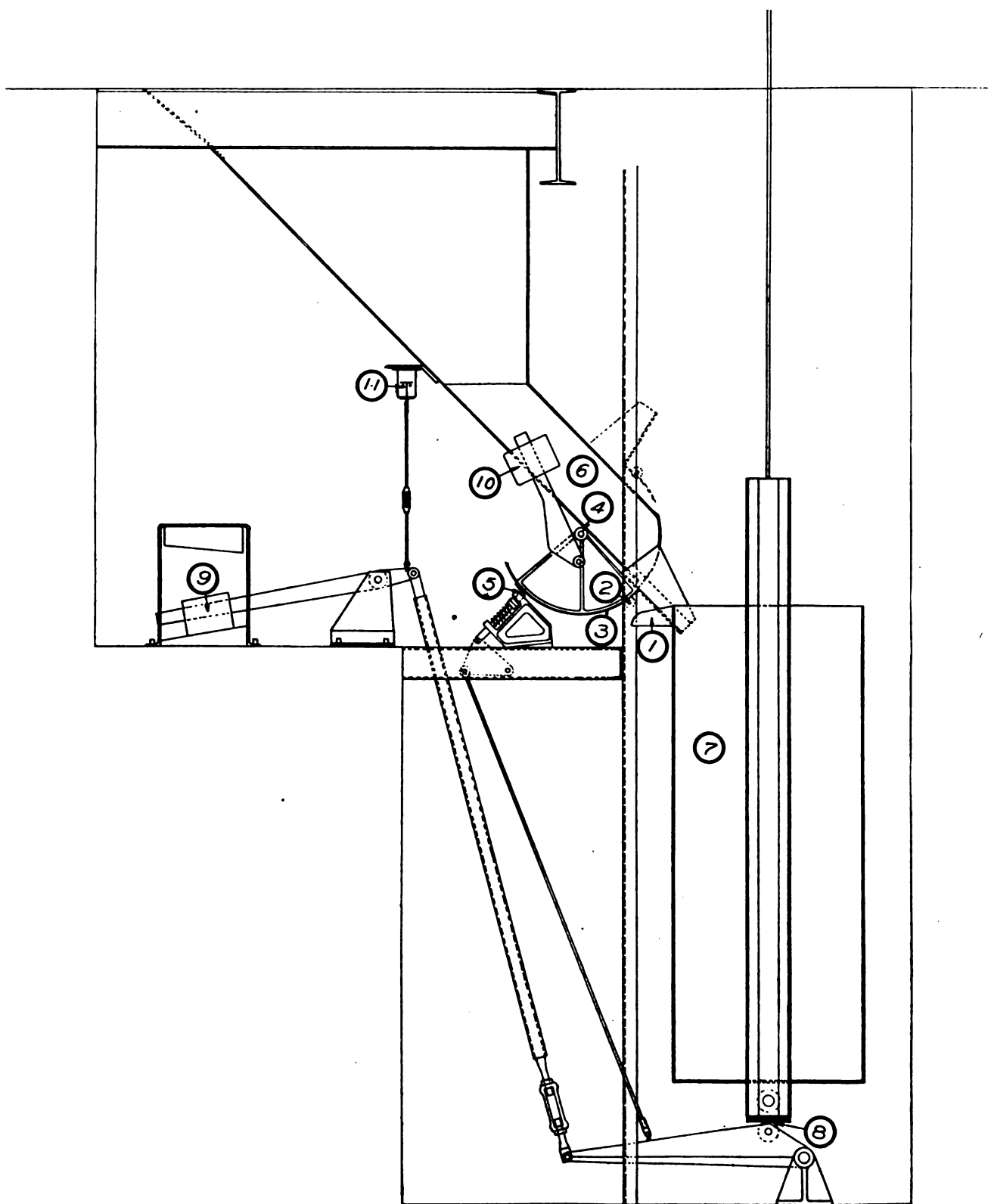


Fig. 4—Detail of pit mechanism of coal hoist.

can be clutched in or out of its individual stoker drive shaft, and in case of failure of one of the motors or its drive to the line shaft, the line shafts of adjacent boilers can be clutched together, the injured motor drive unclutched and the adjacent boilers be driven from the same motor.

Ash Handling.

The general arrangement of the ash handling equipment is shown in Figs. 2 and 8. From Fig. 9 it will be noted that each boiler is provided with three ash hoppers. These are shown in detail by Fig. 10. Referring to this figure, it will be noted that these ash hoppers are cast iron, brick lined. Each is provided with a pneumatically operated ash gate, designed by the company's engineers for this particular job, and subsequently quite generally employed elsewhere. The motor ash larry, after receiving the ash from one of the hoppers, runs to the ash hoist pit, where it dumps down a chute into the ash hoist bucket of 50 cubic feet capacity. The ash hoist is driven by 15-hp, 230-volt, dc, compound-wound, motor at 850 rpm, and is semi-automatic in that when it is loaded and started by the operator, the bucket is raised to the top, dumped into the ash bin of 5,000 cubic feet capacity, which is located above the coal unloading

track and then returns to the starting position and stops. Ashes are discharged at the bottom of the ash bin into cars and removed from the plant.

Economizers.

As is seen by reference to Fig. 2, the gases leaving the boiler ascend vertically through the lined breeching to the economizers located above the boilers and coal bunkers. The gases entering the economizers then pass directly across the boiler house, as shown by Fig. 9, the final gas being discharged on the opposite side of the boiler house from the boiler from which it came.

Economizers were furnished by Green Fuel Economizer Company, and consist of 520 cast iron tubes, 12 feet long, arranged in 52 sections, each section containing 10 tubes. These economizers are special in that the counter current principal is employed. Each economizer is divided into three groups of tubes, the water entering at the bottom of the first group, which is at the cold gas end and flows up through the first group of tubes. It is then carried to the bottom of the second group of tubes and up through this group and then to the bottom of the third tube group. Passing up through this group, it is finally delivered at the top of the third group at its maximum temperature, ready

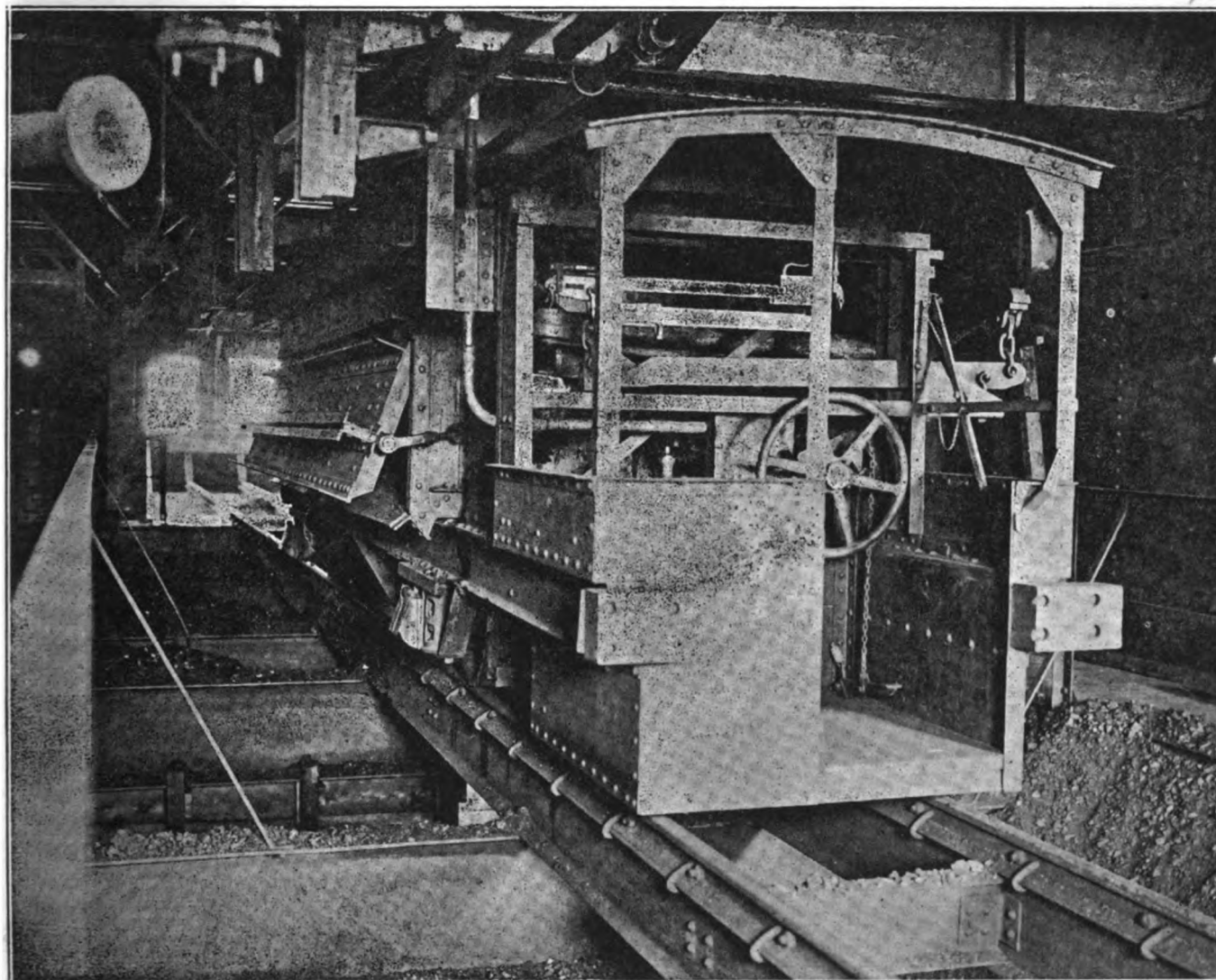


Fig. 6—Motor driven coal larry with subtracting scale beams.

for feed to the boilers. Each economizer is provided with three safety valves and valves for relieving air. Each economizer is equipped with mechanical scrapers and has three soot hoppers. The soot is removed from these hoppers by a steam jet conveyor, which carries it to the soot hopper in the basement, one of which is provided for each pair of boilers.

Induced Draft Fan.

Each economizer is provided with one No. 8 type "RR" Green radial flow fan, each having a capacity of 84,000 pounds of gas per hour at 350 degrees F. when operating at 690 rpm, and creating a draft of 6 inches of water column. These fans are each provided with a short venturi stack, having a diameter of 7 feet at the top and tapering to 5 feet 4 inches at the bottom; taper is accomplished in 11 feet. These fans are driven by 180-hp Kerr 8-stage condensing or non-condensing steam turbines, capable of carrying full load, or load and one quarter with any steam pressure down to and including 70 pounds gauge, whether operating condensing or non condensing, a by-pass valve being employed for the non-condensing condition and an overload valve being employed for the load and one quarter condition. These turbines also have additional nozzles drilled and plugged so that they can carry load and load and one quarter non-

condensing with any steam pressure down to and including 70 pounds of gauge if the plugging of the nozzles is removed. The speed of these units is limited by a direct driven governor, and protected by the usual overspeed trip.

Forced Draft Fans.

There is one No. 5 type "RB" Green Radial flow fan provided for each boiler. Each has a Louvre type damper and discharges up into the main air duct at 45 degrees. This duct is provided with a damper between each pair of boilers on that side.

Each of these fans have a capacity of 60,000 cfm against 6 inches static when operating at 1,350 rpm.

These fans are driven by a Kerr 8-stage condensing or non-condensing steam turbines, similar to those employed for driving the induced draft fans, except that these are rated 130 hp.

Regulation.

The speed of each of the forced draft fans is regulated by a Mason balanced valve, controlled by a Mason extra compensated, high pressure, regulator, actuated by the steam-main pressure.

The speed of each of the stoker motors is regulated also from the steam-main pressure by an independent, Mason, extra-compensated, high pressure, regulator,

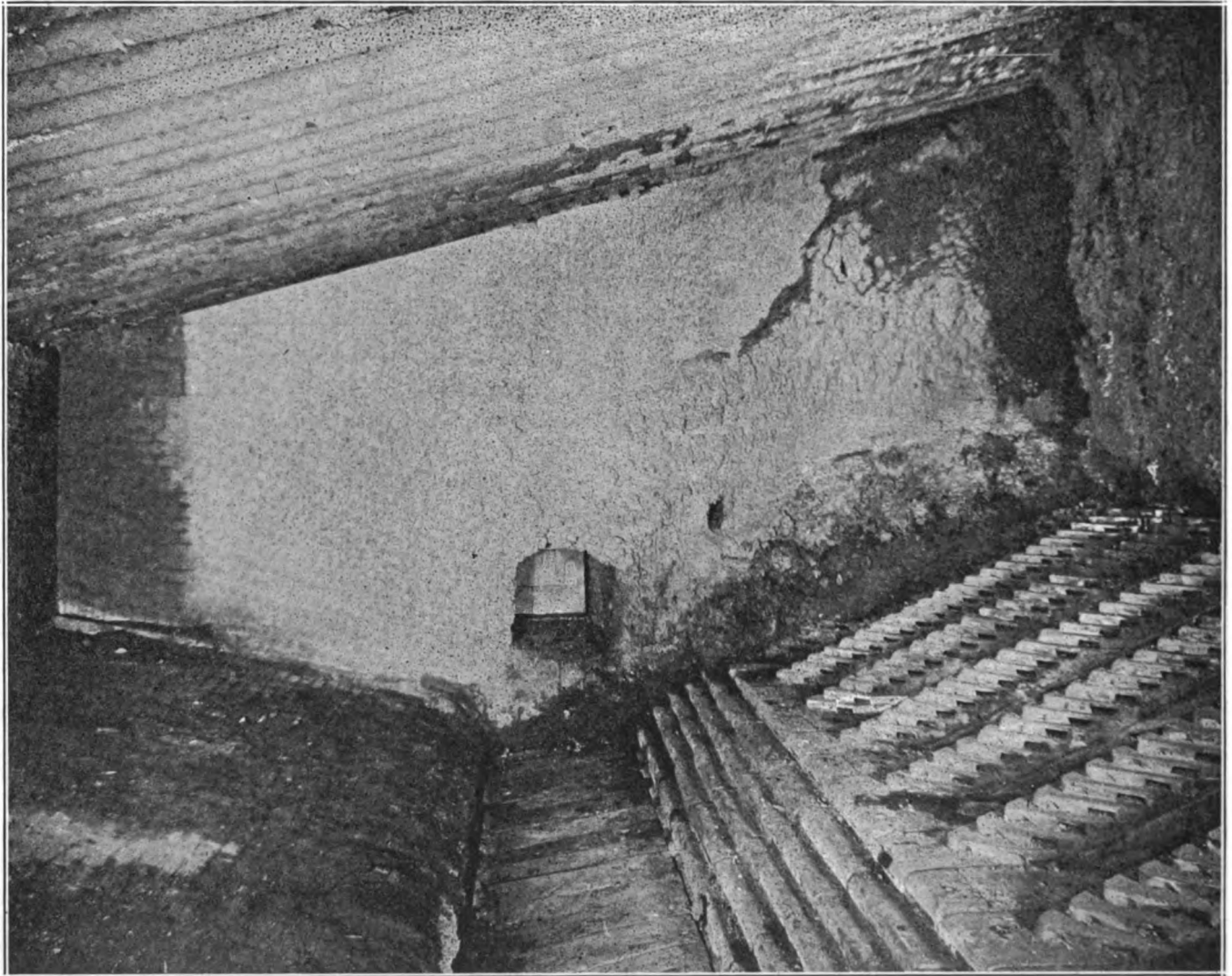


Fig. 7—A view of the Republic Iron & Steel Company furnace and boiler arrangement, showing stoker firing under the high end of boiler and tubes exposed to radiant heat throughout entire length. Original brickwork shown.

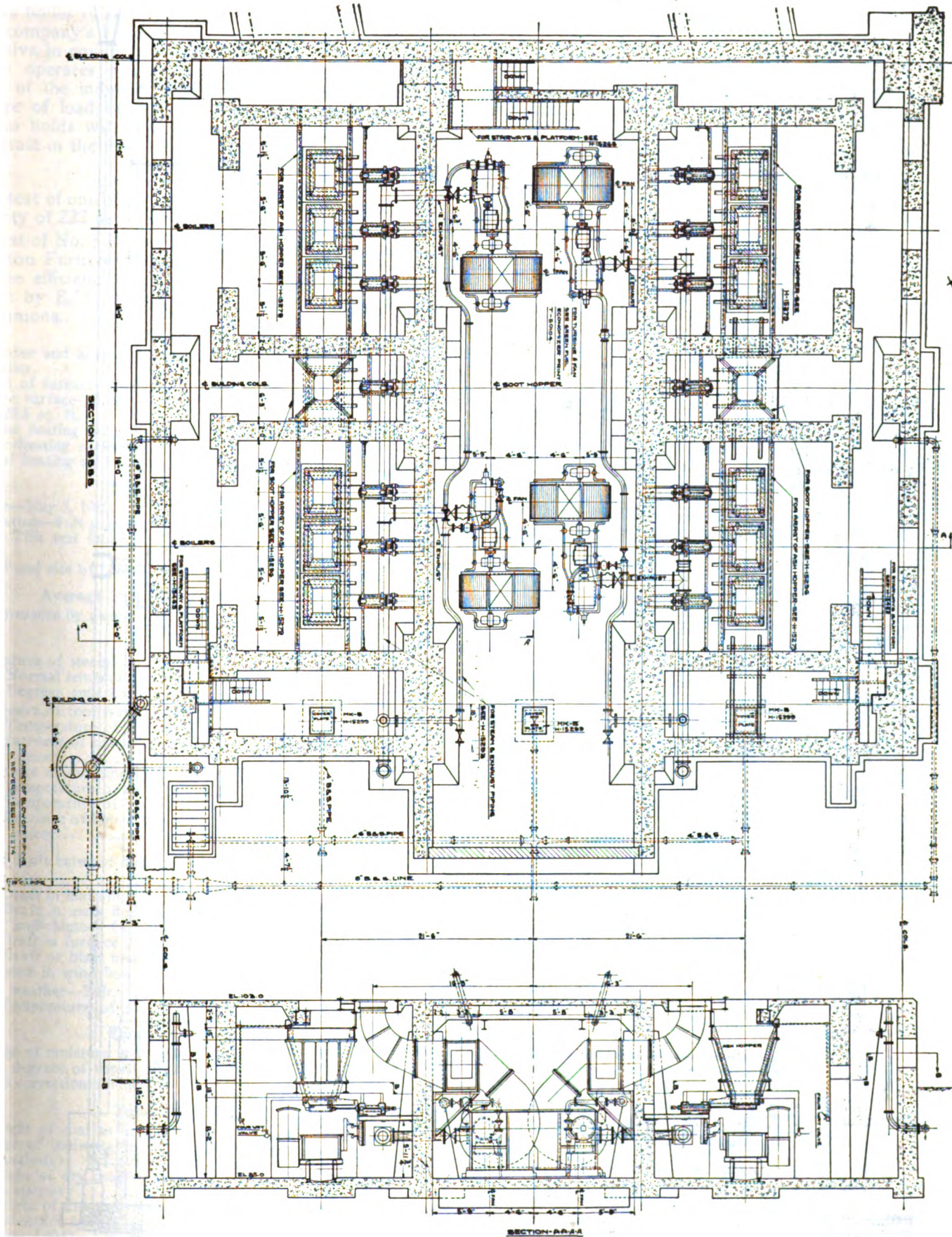


Fig. 8—Plan and elevation of forced draft fan room and ash tunnels.

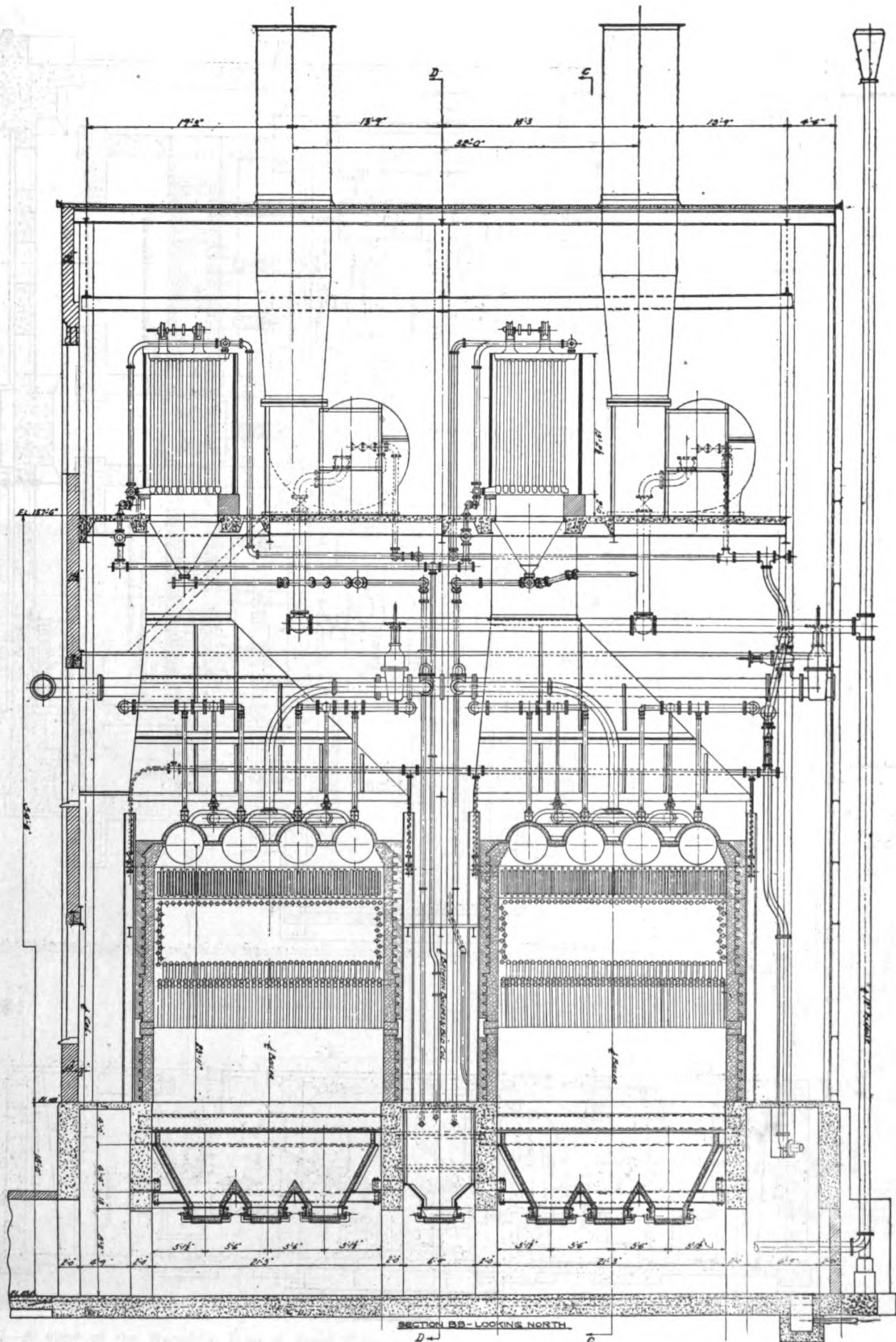


Fig. 9—Arrangements of soot and ash hoppers, boilers, breechings and economizers.

which moves the field rheostat of the stoker motor.

The speed of the induced draft fans is controlled by the boiler furnace pressure, by employing an engineer company's balanced draft diaphragm and balanced air valve in connection with a system of local design, which operates a valve in series with the throttle valve of the induced draft fan turbine. During a change of load of 300 per cent in 10 minutes, this system holds within two one-hundredths of an inch, any draft in the furnace for which it is set.

Test.

A test of one of these units operating at a combined capacity of 222 per cent is here presented:

Test of No. 3 Boiler, located at No. 4 Boiler House, Haselton Furnaces, Republic Iron & Steel Co., to determine efficiency at 225 per cent rating. Test conducted by E. L. Young, under the supervision of G. C. Emmons.

Dimensions.

Number and kind of boiler—One 1,130 hp horizontal straight tube boiler.

Kind of furnace—Special.

Grate surface—Stoker width, 21 ft. 3 in.; depth, 10 ft. 10 in.; area, 229.5 sq. ft.

Water heating surface—11,296 sq. ft.

Superheating surface—1,785 sq. ft.

Total heating surface—11,296 sq. ft. plus.

Date, Duration, etc.

Date—May 5, 1920.

Duration—4:24 p. m. to 12:32 a. m., 8 hours 8 minutes = 8.133 hours. This test immediately followed a preliminary test of 8 hours.

Kind and size of coal—Crushed lump coal.

Average Pressures, Temperatures, etc.

Steam pressure by gauge—162.5 lbs. per sq. in. gauge.

	Degrees F.
Temperature of steam.....	465
a. Normal temperature of saturated steam.....	372.5
b. Degrees superheat	92.5
Temperature of feed water entering boiler.....	246
a. Temperature of feed water entering economizer.....	156.5
b. Increase of temperature of water due to economizer	89.5
Temperature of escaping gases leaving boiler.....	545
a. Temperature of gases entering economizer.....	512
b. Temperature of gases leaving economizer.....	325
c. Decrease of temperature of gases due to economizer	187

Force of draft between damper and boiler:

Last pass	.526 ins. water
a. Draft in main flue near boiler.....	.37 ins. water
b. Draft in main flue between economizer and chimney (draft at fan economizer).....	1.18 ins. water
c. Draft in furnace	.098 ins. water
d. Draft or blast in ashpit:	
Pressure in wind box.....	1.91 ins. water
State of weather—Fair.	
a. Temperature of external air.....	67.7 deg. F.

Quality of Steam.

Percentage of moisture in steam or number of degrees of superheating	92.5 deg. F.
Factor of correction for quality of steam.....	none

Total Quantities.

Total weight of coal as fired.....	60,985 lbs.
Percentage of moisture in coal as fired (by analysis)	1.72 per cent
Total weight of dry coal.....	59,936 lbs.
analysis)	1.72 per cent
Actual weight of ash and refuse, wet.....	8,830 lbs.
Total combustible burned.....	52,734 lbs.
(59,936—5,604)—1,598 = 52,734	
Percentage of ash and refuse based on dry coal	12.01 per cent
Ash in dry coal, analysis.....	9.35 per cent
Total ash and refuse = .0935 × 59,936 =	5604 lbs.

Moisture in item 22, by analysis.....	18.44 per cent
Dry ash and refuse = (1.00—.1844) = 8,830 =	
.8156 × 8,830 =	7202 lbs.
Ash and refuse per pound of dry coal =	
7,202	
59,936 =	12.01 per cent
Total weight of water fed to boiler.....	608,765 lbs.
Total water evaporated, corrected for quality of steam, ...	Same
Factor of evaporation based on temperature of water entering boiler	1.068
1250.3 — (246 — 32)	
970.4	
Factor of evaporation based on temperature of water entering economizer.....	1.16
1250.3 — (156.5 — 32)	
970.4	
Total equivalent evaporation from and at 212 degrees boiler alone, 608,765 × 1.068 =	650,160 lbs.
Total equivalent evaporation from and at 212 degrees boiler and economizer, 608,765 × 1.16 =	706,167 lbs.

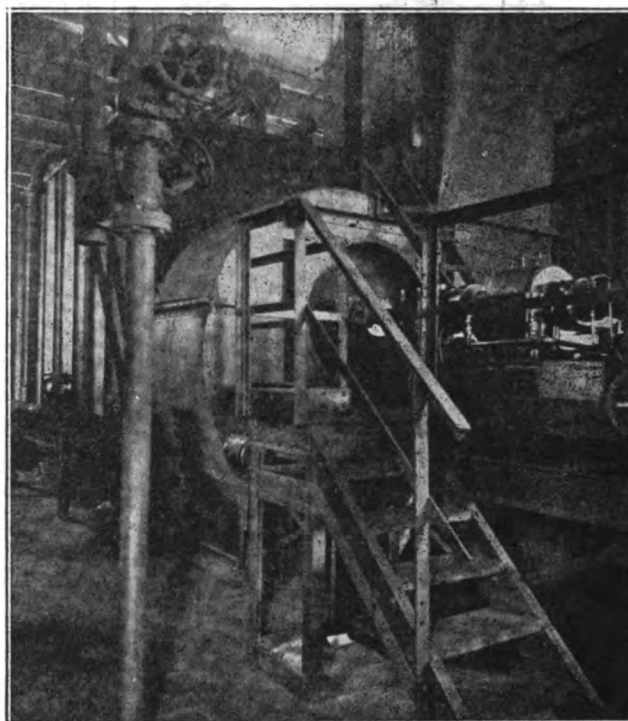


Fig. 17—View showing economizer with cross circulating pipes and induced draft fan.

Factors.

Actual evaporation per pound coal as fired.....	9.981
680,765	
60,985 = 9.981	
Equivalent evaporation from and at 212 deg. F. boiler and economizer, coal as fired...	11.5779
9.981 × 1.16 = 11.5779	
Equivalent evaporation from and at 212 deg. F. boiler alone, coal as fired.....	10.6597
9.981 × 1.068 = 10.6597	
Equivalent evaporation from and at 212 deg. F., boiler and economizer, dry coal.....	11.79
11.5779	
(1.00 — .0172) = 11.79	
Equivalent evaporation from and at 212 deg. F., boiler alone, dry coal.....	10.846
10.6597	
(1.00 — .0172) = 10.846	

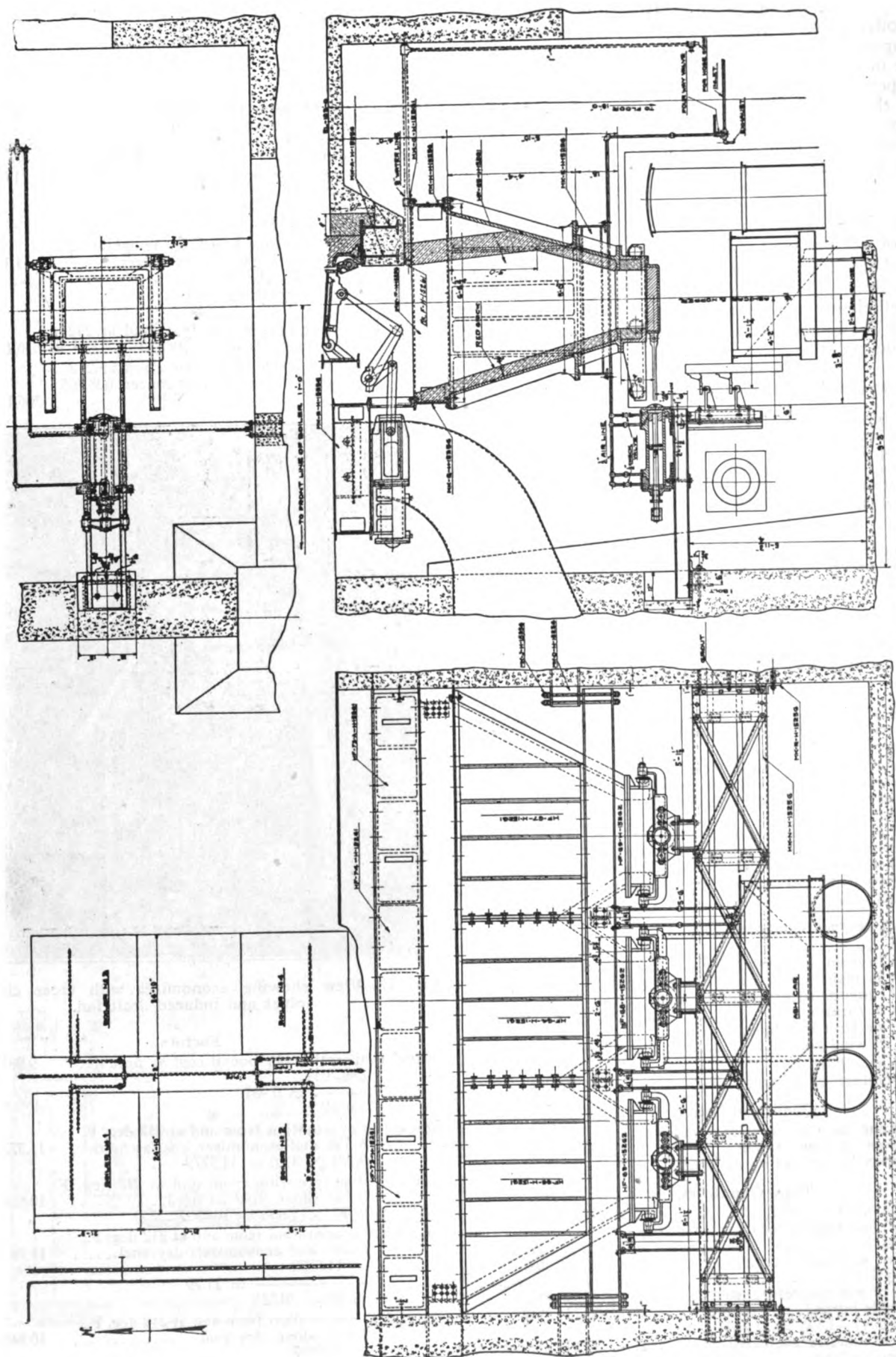


Fig. 10—Detail of ash hopper, pneumatically operated ash gates and larry.

Evaporation per hour from and at 212 deg. F., boiler and economizer.....	86,827 lbs. per hr.
$\frac{706,167}{8.133} = 86,827$	
Boiler hp developed, boiler alone.....	2317 hp
$\frac{79,941}{34.5} = 2317$	
Boiler hp developed, boiler and economizers.	2517 hp
$\frac{86,827}{34.5} = 2517$	
Rated capacity per hour from and at 212 deg. F.....	38,985 lbs per hr.
$1130 \times 34.5 = 38,985$	
Rated boiler hp	1130 hp
Percentage of rated capacity developed, boiler alone	205.0 per cent
$\frac{2317}{1130} = 205.0$	

Rated boiler hp	1130	hp
Percentage of rated capacity developed, boiler alone	205.0	per cent
$\frac{2317}{1130} = 205.0$		

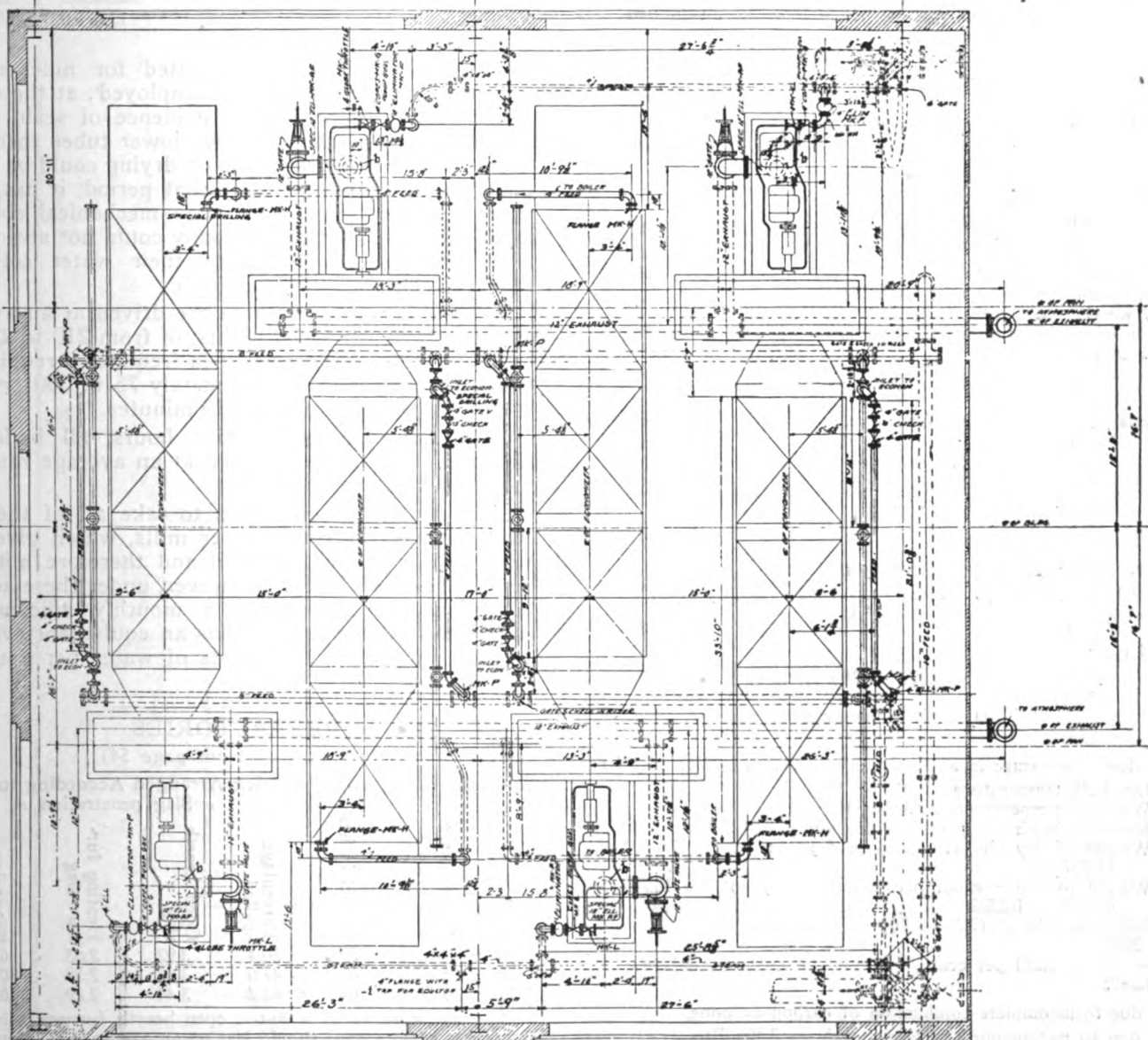


Fig. 16—Arrangement of economizers, induced draft fans and turbines.

Percentage of rated capacity developed, boiler and economizer 222.7 per cent
 $\frac{2517}{1130} = 222.7$

Average Flue Gas Analysis.

In combustion chamber immediately over fire

CO₂ — 13.3 per cent
 O₂ — 5.15 per cent
 CO — 0 per cent

In last pass of boiler

CO₂ — 12.0 per cent
 O₂ — 7.15 per cent
 CO — 0 per cent

In gas passage entering induced draft fan

CO₂ — 9.0 per cent
 O₂ — 8.77 per cent
 CO — 0 per cent

Heat Balance.

Heat absorbed by boiler and economizer..... 82.46 per cent
 $13,875 \times .8246 = 11,441.0$ Btu
 Loss due to moisture in coal..... .147 per cent
 $13,875 \times .00147 = 20.416$ Btu
 $1.72 \div (100 \div 1.72) = 1.75$
 $.0172 (212 - 70) + 970.4 + 48 (325 - 212)$
 $\frac{13,875}{13,875} \times 100 = .1472$

Loss due to moisture formed in burning hydrogen, 525 Btu

$\frac{525}{13,875} \times 100 = 3.784$ per cent

Hydrogen equals 5 per cent

$0.05 \times 9 [(212 - 70) + 970.4 + 48 (325 - 212)] = 525$

Loss in dry chimney gases..... 1,211.0 Btu

Fixed carbon in coal by analysis = 55.38 per cent

Total weight, fixed carbon, $59,936 \times .5538 = 33,193$ lbs.

Carbon in volatile matter = $0.9 (35.27 - 14.0) \times 100 = 19.14\%$

Total carbon in coal

$55.38 + 19.14 = 74.52$ per cent
 $59,936 \times .7452 = 44,663$ lbs.

Gas analysis leaving economizer

CO₂ = 9.0 per cent
 O₂ = 8.77 per cent
 CO = 0 per cent
 N₂ = 82.23 per cent

100.00

Weight of dry gas per pound of dry coal =

$\frac{(11 \times 9.0) + (8 \times 8.77) + 7 (82.23) - (.7452 \times (.9638 + .0145))}{3 \times 9.0} \times 1.833 =$
 19.787 lbs.

$19.787 \times 0.24 \times (325 - 70) = 1,211$ Btu

$\frac{1,211}{13,875} \times 100 = 8.727$ per cent

Loss due to moisture in air..... 29.2 Btu

Dry bulb temperature = 70 deg. F.

Wet bulb temperature = 64 deg. F.

Moisture in air per pound of dry air = 0.0127 lbs.

Weight of dry air per pound of dry coal = $19.787 - 1 = 18.787$ lbs.

Weight of water vapor per pound of dry coal = $18.787 \times 0.0127 = 0.2382$

$0.2382 \times 0.48 \times (325 - 70) = 29.2$ Btu.

$\frac{29.2}{13,875} = 0.211$ per cent

Loss due to incomplete combustion of carbon = none.

Loss due to unconsumed carbon in ash = 2.806 Btu.

Dry ash and refuse (See above) = 7202 lbs.

Fixed carbon in ash and refuse (See above) = 1598 lbs.

Unconsumed carbon in ash and refuse =

$\frac{1598}{7202} \times 100 = 22.2$ per cent.

$\frac{c \times C}{100} \times 14,600$

$\frac{.1201 \times 22.2}{100} \times 14,600 = 389.4$ Btu

$\frac{389}{13,875} \times 100 = 2.806$ per cent.

Radiation and unaccounted for losses, by difference.... 259 Btu

$\frac{259}{13,875} \times 100 = 1.865$ per cent.

Resume of Heat Balance.

	Btu	Per cent
Heat absorbed by boiler and economizer..	11,441.0	82.460
Loss due to moisture in coal.....	20.416	.147
Loss due to moisture formed in burning hydrogen	525.0	3.784
Loss in dry chimney gases.....	1,211.0	8.727
Loss due to moisture in air.....	29.2	.211
Loss due to incomplete combustion of carbon	0	0
Loss due to unconsumed carbon in ash..	389.4	2.806
Radiation and unaccounted for losses....	259.0	1.865
	13,875.0	100.000

Summary of Performance.

The plant described, operated for nine months without a tube cleaner being employed; at the end of this interval, there was no evidence of scale in the upper 12 tubes and in the two lower tubes there was only a brown slime, which upon drying could be blown off with an air hose. Since that period, it has, however, been necessary to employ mechanical cleaners, due to the fact that the company could not always obtain sufficient chemicals for their water softening plant to continue this condition.

The units in this station are driven at an average rate for 30 days and 30 nights, of from 210 to 220 per cent of rating. The station is frequently required to change rating from approximately 75 to 300 per cent to 350 per cent in less than 10 minutes.

For over eight consecutive hours, all boilers in this station have been driven at an average rating of more than 350 per cent.

The station is employed to take all of the peak loads of the company's lower mills, which gives it a very widely fluctuating load and therefore mitigates against high efficiency. However, under these adverse conditions, the station has a monthly efficiency of more than 80 per cent, or has an equivalent evaporation of more than 11 pounds of water per pound of coal as fired.

REFRACTORIES.

(Continued from page 54)

Table 57—Tests of Silica Brick Arranged According to Mesh.
 (Slag penetration sq. ins.)

Mesh	Apparent specific gravity	Impact inches	Percentage spalled	Open hearth slag	Heating furnace slag	Expansion linear inches per ft.
4	1.66	57	30.4	3.92	2.63	0.156
8	1.62	63	47.6	3.67	2.39	0.159
12	1.58	64	62.2	3.44	2.29	0.159

Normal working of a 90-ton open hearth furnace using producer gas a silica roof should last on an average, 200 heats.

Furnace roof of "x" furnace after 261 heats lost 200 per cent by spalling.

Furnace roof of "y" furnace after 221 heats lost 23 per cent by spalling.

Furnace roof of "z" furnace after 80 heats lost 47 per cent by spalling.

Rolling Mill Department

**The Dominion Iron & Steel Company's New Ship
Plate Rolling Mill.**

By BARTON R. SHOVER.

New Tube Mill in Youngstown

Blaw Knox Plant Now Completed

By DEWITT CLINTON GROVES.

Selecting Proper Size Accumulators

By R. W. SCHUTTE.

Electrically Driven Sheet Mills

By O. NEEDHAM.

The Seamless Steel Tubing Industry

Recent Developments in Electric Mill Drive

Modern Rolling of Special Beams

By F. J. DENK.

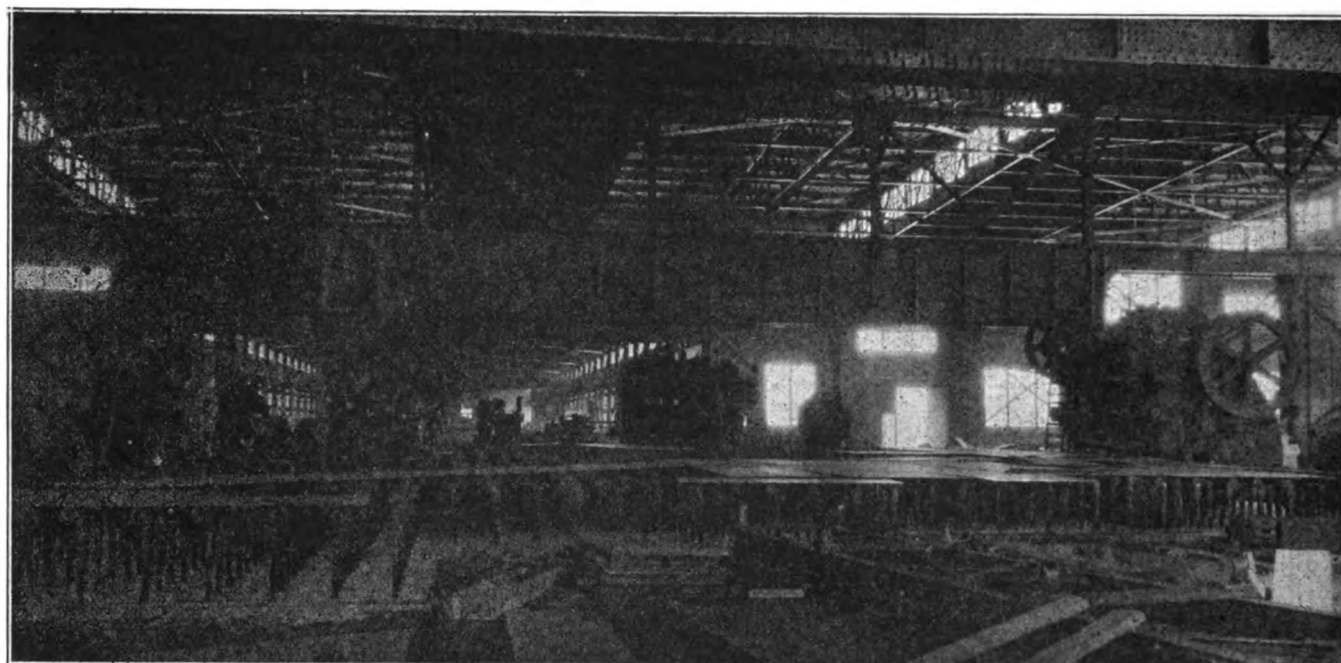


Fig. 1—General view of new plate mill.

The Dominion Iron and Steel Company's New Ship Plate Rolling Mill

Modern Electric Driven Mill in Which Electric Motors Perform Practically all the Work in the Plant From the Picking Up of the Cold Ingots to the Rolling Away of the Sheared Plates.

By BARTON R. SHOVER,
Consulting Engineer.

THIS very latest type of mill, erected at a cost of \$5,000,000, and which, at the press of a button by the Hon. Alexander Johnson, Deputy Minister of Marine and Fisheries, was officially put into operation February 19, 1920, is the result of the negotiations opened during 1918 between the Canadian Government and the Dominion Iron and Steel Company.

The original contract terms and their later modifications are no doubt familiar to all interested persons and need not be discussed. The undertaking is one of national importance and upon its success depends to a considerable extent the advancement and extension of the Canadian shipbuilding industry.

Site.

Immediately the negotiations were concluded the clearing of the site was undertaken. This involved the removal and re-location of seven large structures and numerous small buildings, the re-location of the then existing railway tracks and the transferring of immense quantities of miscellaneous stores material.

The grading to yard level necessitated the removal of 200,000 cubic yards of rock and earth, and the earlier part of this work was carried out under winter conditions which made it especially difficult.

Foundations.

Construction of the foundations included the placing of 18,500 cubic yards of concrete, both plain and

reinforced, for buildings and machinery foundations for the furnaces, motor and mill machinery was distributed from a 90-foot tower with steel chutes, this particular plant being designed and erected on the site for the prosecution of this work. On numerous occasions, with this tower, over 400 yards was placed per day of 10 hours, using a $\frac{3}{4}$ -yard mixer.

It might be noted that the placing of concrete was carried on continuously during the winter months. This was accomplished by pre-heating the materials and covering freshly placed concrete with tarpaulins, using steam and open fires where necessary. It was clearly demonstrated that if concrete was placed while warm and protected for about 12 hours, no further trouble need be expected from frost.

Sewers.

It was necessary to excavate and build an extensive sewer system. This consisted of a reinforced concrete sewer, 3 x 2 feet, about 1,200 feet long, draining the furnace and mill foundation sumps; also tapping all other machinery pits with 12-inch pipe. The sewer excavation was about 22 feet deep; the concrete sewer walls were eight inches thick.

Wherever possible, the excavation was dug neat, to avoid the use of outside forms. Collapsible forms were used for the center and these were made in such

a way that they could be readily removed and re-used as the work proceeded.

Buildings.

These cover a total area of 240,000 square feet, or $5\frac{1}{2}$ acres, and are of the most modern mill type construction, consisting of concrete foundations, structural steel frames, brick walls, with slow burning roof construction, built from $2\frac{3}{8}$ -inch T. & G. plank as finished on the site, and covered with Barret specification tar and gravel roofing.

The steel frame-work involved the erection of 3,500 tons of structural steel, which was supplied and erected by the Dominion Bridge Company.

The construction of these buildings was designed and carried out in the most simple and substantial way. Reinforced concrete sills and lintels were moulded on the site and lifted into place by a locomotive crane, thus avoiding slow and expensive arch work over doors and windows. The erection of the buildings entailed the laying of over 3,000,000 bricks in the walls, the placing of 60,000 square feet of windows and of 5,000 square feet of doors.

Although all buildings are practically fireproof and represent a most permanent construction, as well as embracing very desirable architectural features, the unit cost per square foot was remarkably low, being in the shear building only \$5.00 per foot, with a maximum of \$10.00 in the furnace and mill buildings.

Building and Mill Equipment.

A slab yard and ingot storage 80 x 200 feet is pro-

vided adjacent to the north end of the mill buildings, and is served by a Morgan Engineering Company's 10-ton 3-motor E. O. T. crane. Narrow gauge tracks for the open hearth department pass under this crane and extend into the furnace building, so that hot ingots may be taken direct from the open hearth to the furnaces, or the ingots may be stored in the slab yard and later taken on cars to the heating furnaces.

The heating furnace building is 140 x 227 feet, and contains six gas-fired regenerative side door heating furnaces 11 feet by $7\frac{1}{2}$ inches wide by 51 feet long, inside the buckstays; the width of furnaces, inside brickwork is 9 feet and the length of furnace hearth is 34 feet. Gas and air regenerative chambers of ample proportions are provided underneath each of these furnaces and each one is supplied with a self-supporting steel draught stack 5 feet inside diameter of brickwork and 130 feet high, above the furnace hearth level. Hand-operated reversing valves are used on the stack flue.

Debenzolized oven gas with a thermal value of 560 Btu is used for fuel. This gas is brought through a 24-inch main from the coke oven plant (situated half a mile distant) and, as it is not preheated, both air and gas regenerators are used for preheating air. However, the arrangement of valves, flues and ports is such that both gas and air may be regenerated in case coke oven gas should be temporarily unavailable, and it should become necessary to use producer gas for fuel. Each furnace has four brick-lined cast iron

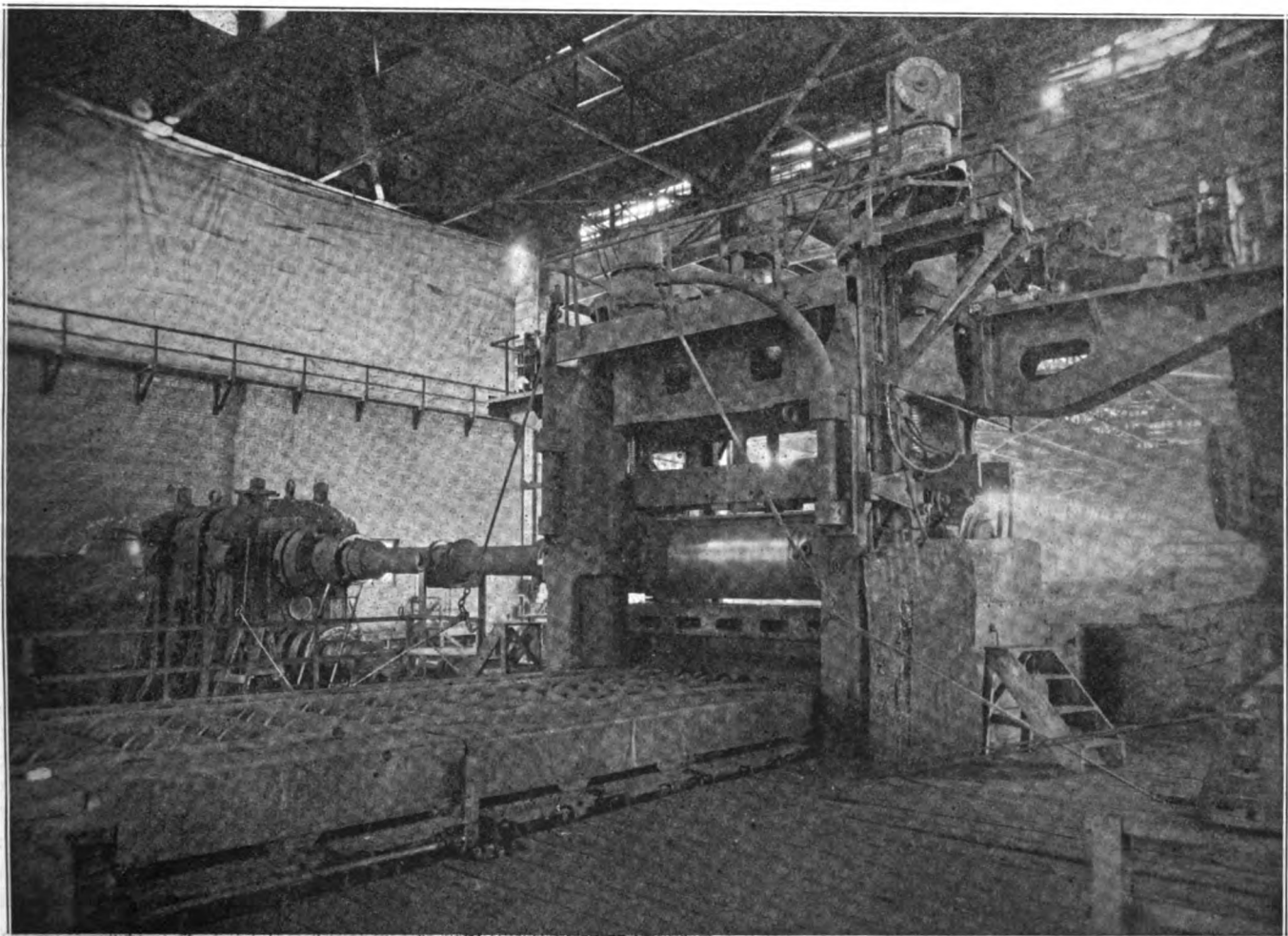


Fig. 2—The plate mill.

doors 8 feet 6 inches from center to center, the width between door jambs being 6 feet, and the clear height from foreplate to skewback 4 feet. The furnace doors are individually operated by General Electric Company motors acting through a worm-gear crank motion. The water-cooled door jambs and skewbacks are of welded steel, Blaw Knox patent.

For average operation is estimated that the coke oven gas consumption will be 9,000 cubic feet per ton of ingots heated, while the water consumption per furnace for jambs and skewbacks will be about 120,000 imperial gallons per 24 hours. Venturi meters of the recording-indicating and integrating type are used for measuring both gas and water on these heating furnaces.

It may not be amiss here to refer briefly to the method used for erecting the heating furnace stacks, which, as previously stated, are 135 feet high and 5

motely controlled from a pulpit at the north end of furnace building. It will be noted that all heating furnaces are arranged in plain view of the mill operator—a very desirable feature from the standpoint of operating efficiency.

The mill building proper is 80 feet 10 inches by 250 feet in plan, and houses the mill motor and mill, together with its tilting tables and auxiliaries, operating pulpit, roll shop, roll rack, salt bin and scale pit. The entire building is commanded by a Morgan Engineering Company's 6-motor E. O. T. crane equipped with 50-ton main hoist and a 10-ton auxiliary hoist. A brick wall separates the motor room from the mill proper. This wall extends from floor level nearly to the crane girders, a fireproofed canvas curtain being arranged to close the opening between the top of this wall and the roof, so that by raising this curtain the 50-ton crane may serve the motor room. It will be

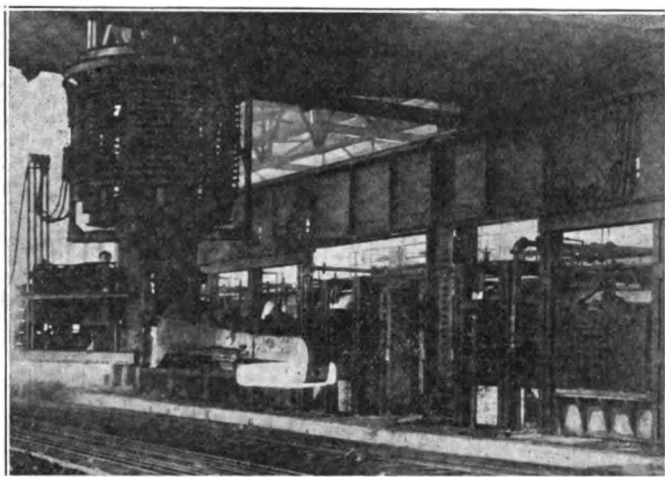


Fig. 3—Crane taking hot ingot from heating furnace to rolls.

feet inside diameter; with heavy self-supporting bases.

It was decided that the quickest and cheapest way to erect these stacks was to assemble, rivet and paint them on the ground, and then hoist them into place. In order to do this, an A-frame was hastily built from stock lumber. When completed, the hoisting frame, or set of shear legs, was 85 feet high. The stacks weighed about 24 tons each. (See Fig. 3).

The tackle used was a 3.4-inch steel cable, roved through two 3-sheave steel blocks, using a standard gauge locomotive for the main lift and a locomotive crane to take the weight of the base until the main hoist had lifted the stack to a vertical position. The stacks were reinforced with wood bracing, inside and out, at the point where the sling was attached, which was about 65 feet high from the base, or approximately 10 feet above the center of gravity.

The workmen were much pleased with this method of construction and showed their enthusiasm by reducing the time of erection in each case, until the completion of the last stack, which was lifted and bolted in place in the remarkably short period of 22 minutes.

Two Morgan Engineering Company's 10-ton, 5-motor revolving slab chargers, having a span of 55 feet, are arranged to serve the six heating furnaces in conjunction with an electrically operated ingot chariot arranged on the center line between furnaces. This ingot chariot and all 24 furnace door hoists are re-

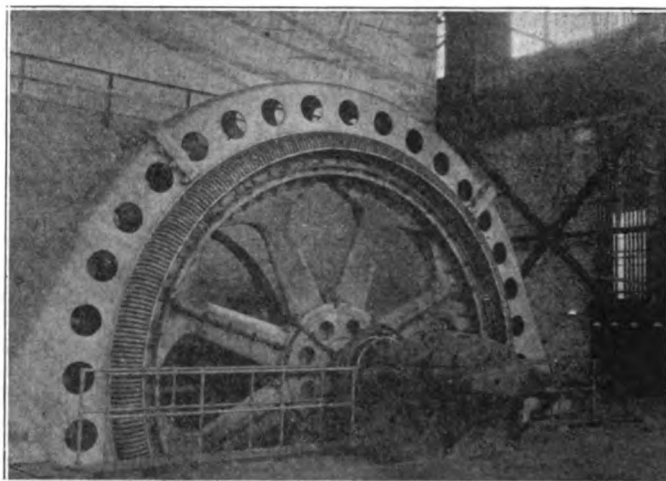


Fig. 4—Main roll motor 4000 hp, 82 rpm, 6600 volts.

noted that standard gauge railway tracks are arranged under either end of the 50-ton crane runway.

Mill.

This is known as a 110 by 36-inch three-high plate mill and is of the Lauth type. It consists of one stand of rolls served by tilting tables and is driven by a 4,000 hp, 82 rpm motor through a set of cut herring-bone pinions. The middle pinion is driven by the motor while the upper and lower pinions are connected to the upper and lower mill rolls respectively, through leading spindles and coupling boxes. The pinion gear reduction is about 10 to 6, so that the mill is driven at about 49 rpm. The top and bottom rolls are 36 inches in diameter and the middle roll is 24 inches in diameter; the length of all rolls is 110 inches between necks, and the horizontal distance between mill housings is about 113 inches, thus the widest sheared plate that it is commercially practical to produce is about 98 inches. The mill screw drive is located on top of housings and consists of two 100 hp motors connected to a common shaft and driving screws through a worm wheel reduction. These motors are electrically connected for series-parallel operation. The front and back tilting tables are each about 30 feet in length and each supports 21 live rolls. Two 60 hp motors drive the live rolls on each tilting table. The power for raising and lowering the tilting tables is supplied by two 150 hp motors acting through a gear reduction

and a crank motion. The tables are balanced by a closed hydro-pneumatic system acting on the crank motion through hydraulic cylinders and a hydraulic accumulator. The top is hydraulically balanced while the middle roll is mechanically balanced and electrically raised and lowered by means of two 150 hp motors.

Main Drive.

The mill motor is the General Electric Company's type 1, 88 pole, 4,000 hp, 82 rpm, induction, 3-phase 60 cycle, form M, 6,600 volts. The flywheel is direct connected, mounted between its own bearings, and weighs approximately 155,000 pounds. This flywheel has a diameter of 22 feet 7 inches while the rotor has a diameter of 21 feet 4 inches. The W. R.² of rotating parts is approximately 20,000,000 pounds. The total weight of motor and flywheel is about 659,000 pounds. The maximum running torque in pounds at 1-foot radius is 700,000.

The 1,000-kilowatt motor generator set is provided for furnishing direct current at 250 volts for all other motors used for the mill and its auxiliaries. The General Electric Company have supplied the entire electrical equipment.

The most important item, perhaps, in the building of this mill was the construction of this huge motor, which may be briefly described as follows:

On account of the enormous weight involved, it was necessary to assemble the stator frame, rotor, spider, press in the shaft, build the laminated cores, and to wind both stator and rotor, after the motor was placed in position on the base. The stator and rotor cores each contain over 60,000 laminated sheets of 14 mills thickness; these sheets were placed in position one at a time and were so placed as to break joints, thus making, as nearly as possible, a solid core. The cores are 26 inches in width, thus making it necessary to press several times during construction in order to place the proper amount of sheets in each core. This work was accomplished by means of a special pressing outfit.

The stator winding is what is known as open slot construction. Each coil is a complete unit in itself and, in the event of any coil being injured, it can readily be removed and another substituted. These coils are held in position by fibre wedges, driven into grooves in the top of the coil slots. In addition to this, the projecting ends of the coils are tied down to a heavy supporting ring, thus doing away with the chance of coil vibration. These coils were tested from time to time as they were placed in position, to make certain that they were in perfect condition. The testing was made with double voltage, that is 12,200 volts. After the coils were all placed in position, and before the three phases were connected together, a double voltage test was made between the phases.

The rotor winding is what is known as the semi-open slot construction; the winding being held in position by wedges tightly driven under the projecting parts of the slot teeth; the projecting ends of the windings are clamped down to supporting flanges. This is accomplished by means of sectional bands. In the event of a damaged coil, these bands can readily be removed and a new coil substituted. These coils were also tested at double voltages.

The pressing in of the rotor shaft was accomplished by means of a hydraulic jack; the pressure required was 370 tons. The shaft is 20 inches in diameter, and has a bearing surface 50 inches in length.

The control equipment for this motor consists of a master controller and six automatic current limit accelerating points and one plugging point, both forward and reverse, six of which may be hand-controlled from the master controller. In case of failure of voltage while running, the master controller must be returned to the off position before the equipment can again be started. Sufficient resistance is connected in the slip ring circuit, to give approximately 15 per cent slip at full load.

The flywheel consists of two sections of hub and spider and four sections of rim. The total weight of the flywheel rim is 120,000 pounds, and the total weight of the motor and flywheel is 659,000 pounds. The peak loads of the motor are absorbed by the 120,000 pound flywheel rim.

The motor is built to withstand an overload of 125 per cent for two hours and a momentary overload of 250 per cent. The installation of the motor and its auxiliary equipment was carried out under the supervision of the General Electric Company's engineering construction staff.

During the test, when this motor was first started, after shutting off the current, the motor drifted for an hour and forty-five minutes, which was good evidence of the splendid balance and alignment which had been attained by the erecting engineers.

The hot-bed building, about 100 feet wide and 560 feet long, is equipped with a crane runway over its entire length for a Morgan Engineering Company's 10-ton, 3-motor, E. O. T. crane. A standard gauge railway track is arranged to enter this building underneath the crane runway. Plate mill machinery housed by this building consists of the runout tables, plate leveller, hot bed chain conveyor, inspection turn-up, layout chain conveyor, and rotary shears and tables.

The shear building is 300 x 250 feet in plan and is equipped for its entire length with three 96 feet 6-inch crane runways, each supporting a Morgan Engineering Company's 10-ton, 5-motor, double trolley, E. O. T. crane. This building houses the 108 by 14-inch cross-cut shears, 156 by 14-inch trimming shears, 114 by 24-inch trimming shears, 5 scrap shears and two 10-ton dial scales. The castor bed is arranged for the easy handling of plates from all shears to the scales. They are also excellent track facilities for shipping, as well as extensive plate storage space, which is so necessary for the economical operation of plate mills.

All machinery for the plate mill, except the 144-inch shear, was furnished by the United Engineering & Foundry Company, of Pittsburgh, Pa. The 114 by 24-inch shear was furnished by the Morgan Engineering Company, of Alliance, Ohio. All cranes and mill machinery are motor-driven with General Electric Company's 230 volt equipment. Auxiliary apparatus, such as shear plate grinder, test piece milling machine, air compressor, hydraulic pump, etc., are also motor-driven.

The supply of fresh water required for this mill amounts to about 1,500,000 imperial gallons per 24 hours. The cooling water for the heating furnaces is returned to a cooling pond and re-circulated, while the cooling water for the mill, which is contaminated with mill scale, grease and salt, is run into the sewer.

Power for the operation of the plate mill is supplied by a G. E. 5,000-kw turbo generating unit in the company's new No. 3 power house (erected at a cost of \$1,000,000) and is transmitted about a mile at 6,600 volts.

Extensions to the open hearth building were necessary, in order to provide room for bottom casting the slab ingots as required for plate mill consumption. This auxiliary feature of the main installation \$600,000 and, without considering the necessary extension to the electrical power plant facilities, brings the total cost of the plate mill to \$5,000,000.

The work was entirely supervised by the steel company's engineering and construction departments, and the erection of all buildings and machinery, with the exception of the structural steel and the main motor, was carried out by the company's engineering

and construction forces. It is a remarkable fact that, of nearly 4,000 bolts in the machinery and building foundations, not one had to be changed; this testifies to the accuracy with which the drawings were prepared and the work executed. The entire project represents the latest practice in the manufacture of steel plates, and aside from the fact that it is a most creditable extension to the steel plant of the Dominion Iron and Steel Company, Limited, it cannot but be a most valuable addition to the manufacturing wealth of Canada.

New Tube Mill in Youngstown

Youngstown Sheet and Tube Company Have Completed a New Mill to Be Used in Manufacturing Lap-weld Pipe—Several Unique and Distinctive Improvements Feature the Mill.

THE Youngstown Sheet & Tube Company, at their East Youngstown plant, put in operation July 15, 1920, a tube mill which is designed to finish from 4 to 10-inch lap-weld pipe.

The distinctive features of the mill are the heating system, the absence of steam machinery, the elimina-

tion of all exposed wiring and the grouping of controlling apparatus at a minimum number of points.

of Pittsburgh, Pa., much study being spent on the lighting, ventilating and heating system. The roof of the building with the Pond type inverted monitor roof, and equipped with Lupton top-hung sash and operates in the monitor, and with United Steel sash, furnished by the Trussed Concrete Company, for the side walls.

The side wall sash consists of two rows of continuous sliding sash each five feet high, the full length of the furnace building; the threading floor, having brick walls, is provided with ample pivoted ventilating sash.

Building Annex.

This building which is located on the north side of the mill and adjoining, covers a floor space of 2,530 square feet, is 55 feet wide by 46 feet long, built entirely of brick, and also being amply provided with sliding and pivoted ventilating sash.

In this building well equipped rooms for millwrights, electricians, die, wash and lockers; also offices for both furnace and threading floor foremen are located. In the basement the heating, ventilation system, also the cooling station with the equipment for the cooling of drinking water for the mill are located. The wash and locker rooms are furnished with up-to-date shower baths, clothes hangers and sanitary equipment.

As the floor of the mill building is seven feet above the ground level, large concrete platforms, ramps and walks were built around the mill to facilitate the handling of the finished and unfinished products.

On the west side the platform is 36 feet wide by 60 feet long equal to 2,160 square feet extending out into the skelp yard runway which is at right angles and adjacent to the mill.

The old skelp yard runway which has a crane span of 77 feet 2 inches and a length of 292 feet 6 inches was extended 123 feet together with the mill building.

This crane runway is equipped with two 10-ton cranes.

The platform on the east side extends out into the present warehouse which is also at right angles and adjacent to the mill. It is 36 feet 4½ inches wide and 100 feet 0 inches long, equal to 3,637 square feet.

The crane span of this warehouse is 85 feet 0 inches

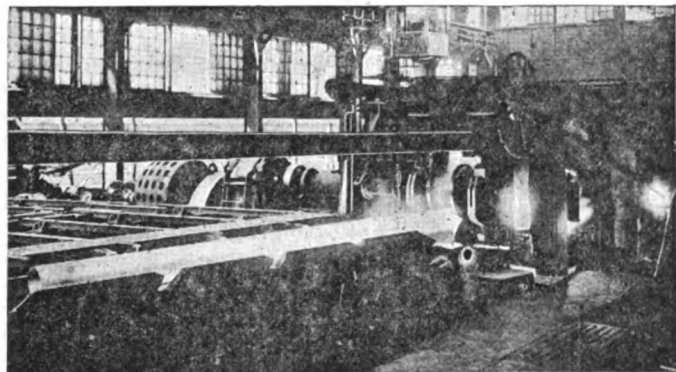


Fig. 1—Welding pipe by lap-weld process.

tion of all exposed wiring and the grouping of controlling apparatus at a minimum number of points.

Building.

The total floor space occupied by the mill is approximately 59,000 square feet.

The mill which is built as one continuous building, 100 feet wide by 475 feet long, consists of two departments as follows:

The furnace department, which is 100 feet wide by 228 feet long, houses both the bending and welding furnaces, conveying machinery, chargers, chill and size rolls, cross rolls, scarfing and welding rolls, draw bench, buggy, turning trough, bar pullers and cooling racks.

The threading floor is 100 feet wide by 247 feet long, housing skids, scales, threading and socket screwing machines, pipe conveying machinery, tester, intensifier, and pipe straightener.

The mill is equipped with two 10-ton cranes, furnished by The Cleveland Crane & Engineering Company, Wickliffe, Ohio.

The building is of steel and brick construction and was furnished by the McClintic-Marshall Company,

by 483 feet 6 inches long. It is equipped with three 10-ton cranes.

The concrete walk on the south side is 6 feet 0 inches wide and runs along the length of the building for 380 feet 0 inches. The walk on the north side is 6 feet 0 inches wide with a length of 113 feet 0 inches.

Furnaces.

The two furnaces are of a regenerative type and of a special design of The Youngstown Sheet & Tube Company, to operate on coke oven gas.

The bending furnace is 24 feet 5 inches wide by 26 feet 3 inches long; the welding furnace is 19 feet 7 inches wide by 28 feet 3 inches long.

Machinery.

All machinery used in this mill is of a heavy standard mill type class, with the exception that several special features were incorporated in the design of some of the machines which were furnished by The Youngstown Sheet & Tube Company, to meet their requirements.

These machines were furnished by The Taylor-Wilson Company, and the United Engineering & Foundry Co., of Pittsburgh, Pa.

Electric Power.

Electric power for operating this company's mills is generated at 6,600 volts, 3 phase, 25 cycle, at various generating stations. Substations located throughout the plant receive the power at this voltage and by means of step down transformers or motor generator sets transform to 220 ac or 240 dc at which voltage the power is delivered to the individual mills. All motors are controlled through automatic control equipment located at centralized points, each group of controllers operating motors within a given range. The wiring from control equipment to motor is in steel and fiber ducts embedded in concrete under the floor.

Heating System.

The heating system is of a hot air type and is unique in many respects, being designed to obtain the greatest amount of heating capacity at the minimum amount of cost, and is of a patented type. This was patented by Mr. L. Lee, Consulting Engineer of The Youngstown Sheet & Tube Company.

The furnace is 11 feet 3 inches wide, 33 feet 4½ inches long and 7 feet 10 inches high and designed to burn coke oven gas, in its construction the best quality of fire and silica brick are used. The furnace is mounted on two concrete air ducts (running the full length of the furnace) one for cold air and the other for hot air. The air is heated by drawing the cold air from the floor of the threading building by a large turbo conoidal Buffalo air fan forcing it into the cold air duct, through the inside diameter of a series of 4-foot steel pipes (bent in the shape of a large "U") and into the hot air duct; while the hot gases in the furnace are being drawn over the outside diameter of the pipes by an exhaustor. These gases continue through the exhaustor into the stack which is located on the outside of the building.

The pipes are placed four in a row one above the other, there being 60 rows, making a total of 240-4-inch bent "U" pipes; these pipes are set in with a rust joint, in large cast iron plates which are placed on top of the cold and hot air ducts underneath the furnace. The "U" shape of the pipe as it spans from the cold to the hot air ducts allows for any excessive expansion or contraction which may take place.

Both the exhaustor and air fans are coupled together with an intermediate shaft using flexible couplings. On this shaft a pulley is mounted, pulley being belted to a motor and the whole driven as a unit.

In the coke oven gas line which is piped to the furnace an automatic valve is so arranged that should by chance the supply of cold air be interrupted in the "U" pipes, gas is automatically shut off, thus preventing the overheating of the pipes.

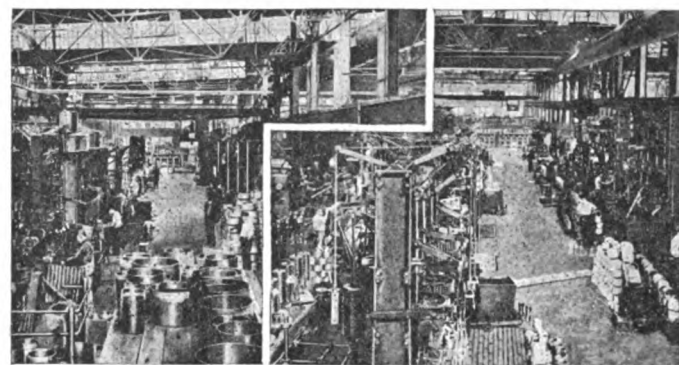


Fig. 2—Where couplings are made for Youngstown pipe.

There are several similar types of this furnace now in operation which are giving excellent results.

The hot air duct which leads from under the furnace, as before stated is located in the basement of the building annex, continuous into the threading building under ground and encircles it, making a complete loop.

Two small branches are led from the main duct to the floor in the corner of each building column which are spaced on 19 feet centers. Mounted on these branches are special designed castings giving an ejector effect, that is, as the hot air is forced out it creates a vacuum on the floor which draws in the cold air, causing diffusion of the hot and cold air throughout the building. This system produces a perfect circulation.

All engineering work on this installation was done by The Youngstown Sheet & Tube Co.

SHEET MILLS OF REPUBLIC IRON & STEEL COMPANY.

Completion early in 1921 of eight modern sheet mills at the Niles plant of the Republic Iron & Steel Co. will give that interest an annual productive capacity of 140,000 tons of blue annealed, black and galvanized sheets and roofing products. Under normal conditions, it is expected the entire complement of mills will produce 12,000 tons per month. The principal products of the Niles plant will be black and galvanized sheets, the blue annealed tonnage ranging from 16,000 to 18,000 tons per year. New units will be operated in preference to the old, after their completion, in case conditions do not justify operation of the whole.

The Niles plant was originally acquired by the Republic company from the old DeForest Sheet & Tinplate Co., which has since virtually gone out of existence. The property consisted of nine sheet mills and one jobbing mill, with a manufacturing site of 225 acres. The Republic company has effected many improvements to the old plant, including the installation of electrical equipment.

Blaw-Knox Plant Now Completed

Modern Hammer Weld Shop Just Put in Operation Completes the General Improvements Being Made by the Blaw-Knox Co. at Their Blawnox Plant—General Description of Equipment.

By DEWITT CLINTON GROVES,
Publicity Director.

THE little town of Blawnox, Pennsylvania, only seven miles from Pittsburgh, and situated on the banks of the Allegheny River, is the home of the world's largest manufacturer of steel forms for concrete work, clam shell buckets, water cooled furnace appliances and one of the foremost fabricators of steel products in general. The plant parallels the Conemaugh Division of the Pennsylvania Railroad, and its shipping facilities are ideal. The plant, itself, consists of two main shop buildings, one 850 by 300 feet, the other 360 by 110 feet, together with auxiliary buildings. The executive staff, engineers, draftsmen and clerical forces are housed in two buildings—one a three-story edifice, constructed of face brick, the other a two-story frame building, giving adequate space for expansion.

Going from the office buildings to the shops we pass through a spacious yard in which is stored large quantities of raw material from which numerous Blaw-Knox products are constructed. Before we reach the entrance to the shop building No. 1, we pass the Blaw-Knox restaurant, which is about equally dis-

tant from offices and shop, and which was especially built to serve a noonday meal to the officials, shop foremen and office forces.

The large shop building is so laid out that all work moves forward from the end in which the raw material is taken in, to the other end from which the finished product is placed on board the cars for shipment. The building is divided into four units or aisles, each devoted to specialized work but so arranged to enable progress of each phase of the work with automatic precision. These large divisions are in turn subdivided into small departments to provide for the manufacture of the many different products which come in each class.

As we progress up the first aisle, the power house is immediately before us where four air compressors are installed which give power to the riveting hammers and other machinery operated by compressed air. The power house also contains two motor generator sets, transformers and switch-board.

Passing along an aisle, flanked on either side with rough steel castings, we next come to the machine shop with its complete equipment of machine tools,

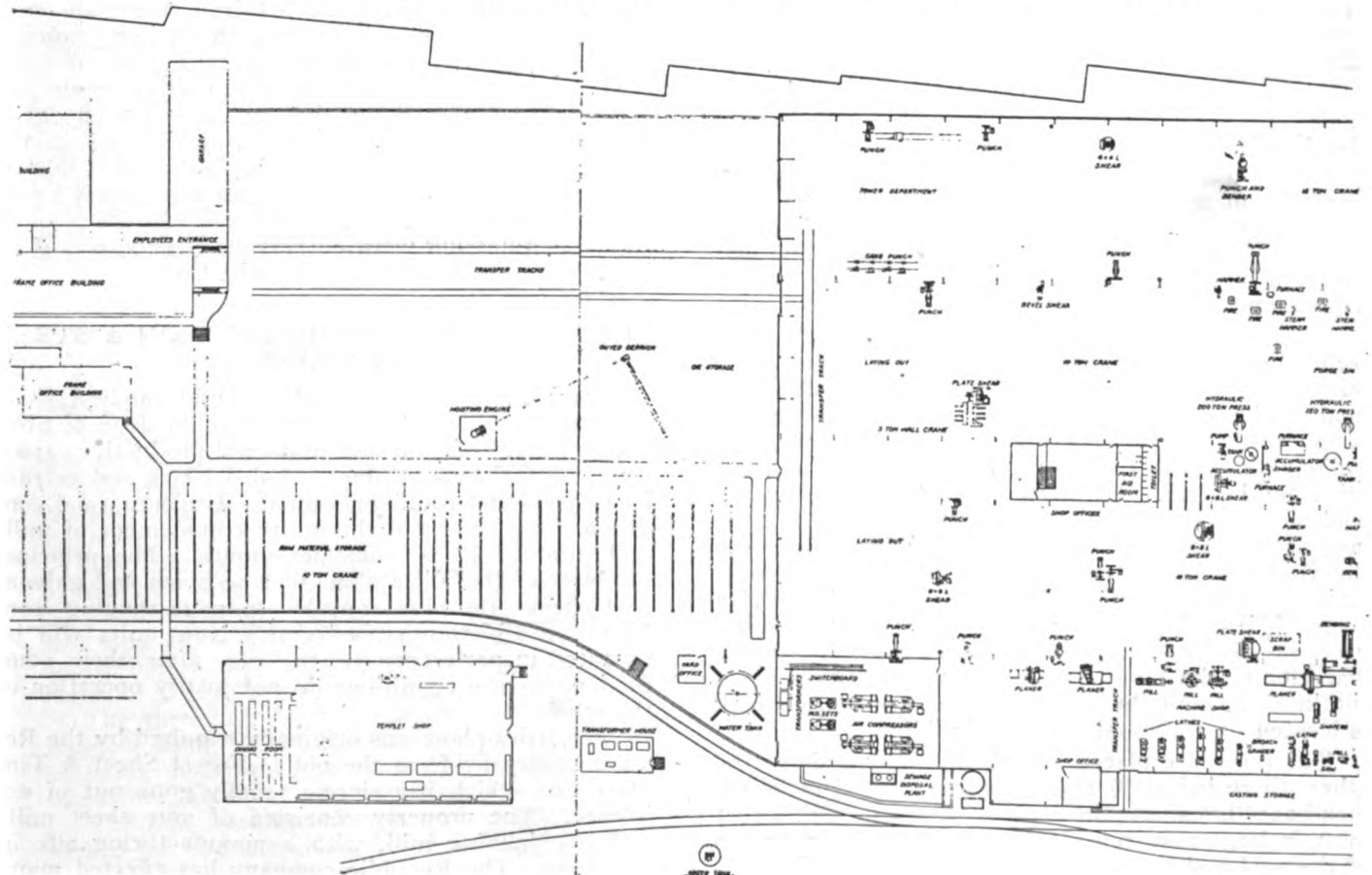


Fig. 1—General plan and

arranged on either side of the aisle. If we pause a minute to note what work is going on, we see on the boring mill nearby, a hinge casting for a clam shell bucket, being bored to a jig so that the hinge pin will fit it accurately. On a large planer, we see a water cooled damper for a blast furnace being planed down to size. After the machine operations on the castings for clam shell buckets have been performed, the castings are transported to the assembly department, which adjoins the machine shop, where the parts are put together to form completed buckets, which are manufactured in many types and sizes to suit the various uses for which clam shell buckets are made.

There is the Speedster, a lever arm clam shell bucket, having great rapidity in action and which is built mainly to handle loose bulk materials; the Bulldog, another lever arm type for handling heavy materials such as broken open hearth slag or ore; the Dreadnaught, extremely strong and sturdy, adapted for heavy excavating and dredging; the Single Line "hook-on" type, which can be operated from a single line fastened to a crane hook, eliminating reeving; the power wheel which is an all around bucket for light rehandling uses; the Collier, a bull wheel bucket with special scoops adapted to rehandling anthracite and slack coal; the Foundry, a single line bucket for handling molder sand and cleaning up around the plant, which is noted for the low head-room it requires.

Adjacent to the assembly department is a powerful testing rig on which each clam shell bucket is tested before shipment.

Adjoining the bucket department is the light form department where Blaw steel road, wall, column and other forms of light character are manufactured. This department is equipped with special machinery for

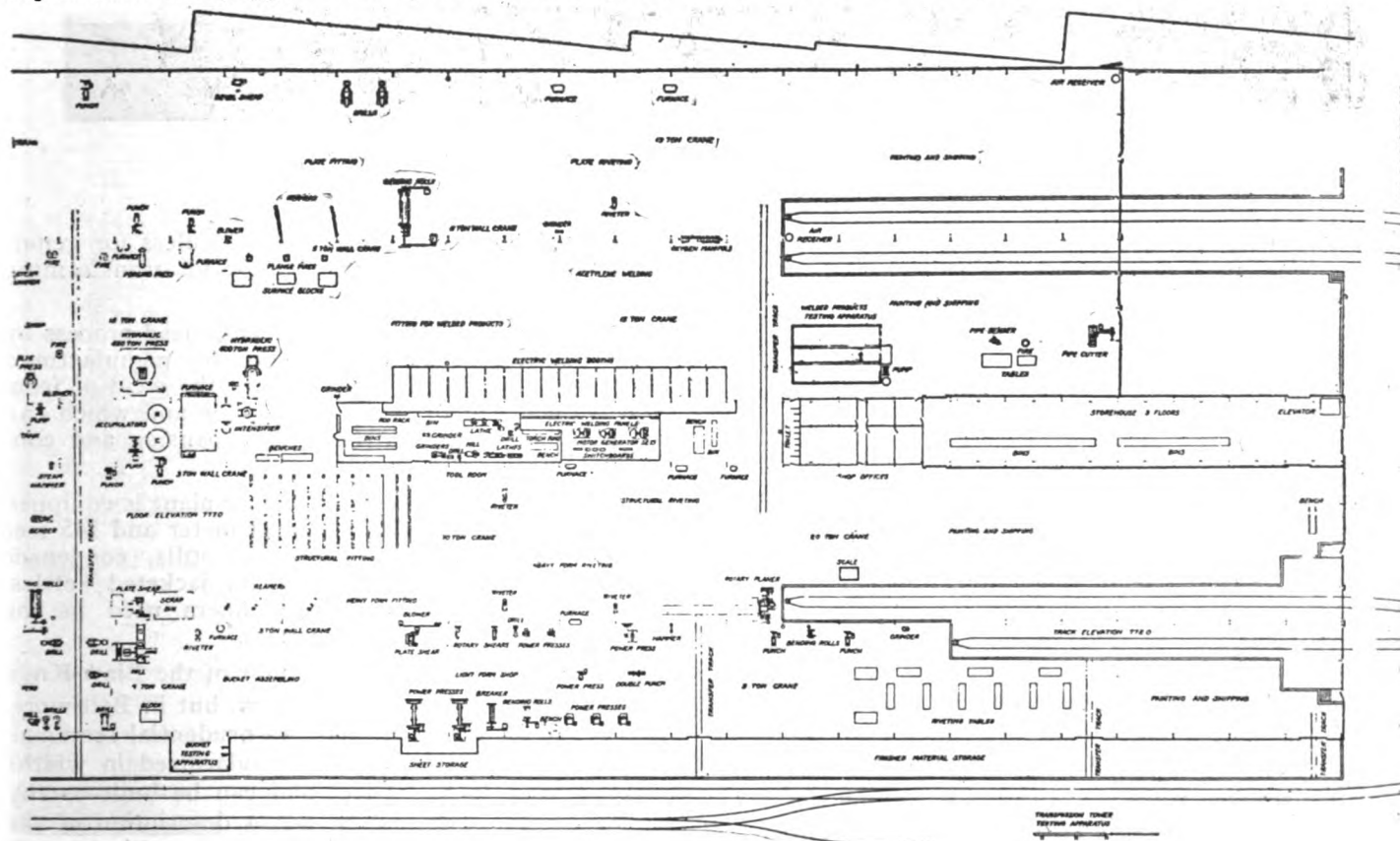
handling this particular work, including shears, punches and powerful power presses.

In a separate department in what is known as the structural aisle of the shop, steel forms are made which are used in the construction of sewers, subways, tunnels, aqueducts, heavy walls and every manner of conduit. The manufacture of these heavy forms is of a more complicated nature than that of the lighter forms as they embody a large amount of work of a fabricated character. Many of these forms are mounted on travelers to enable them to be moved quickly from one location to another and many of them are collapsible, so that they can be taken down while the concrete is still green and passed through the conduit to another section without disturbing the concrete.

Still another section of the structural aisle is devoted to the manufacture of steel arch ribs used in building concrete bridge spans. In the structural department are fabricated buildings, bridges, crane runways and a great variety of other work manufactured from structural steel.

The construction of steel transmission towers for high tension electric transmission lines is a feature of the structural department. These towers are tested by a special testing apparatus by means of which they are subjected to stresses which they would receive in actual use.

We have now arrived at the forge shop where forgings are made for various products requiring steel forgings. Here also steel plates are pressed and flanged on ponderous hydraulic presses. After the steel plates are shaped, they are passed into the oxy-acetylene or electric welding department where the plates are put together into such products as water-cooled ports, doors, frames, shields and many other varieties of welded plate work. After the welded pro-



layout of main building.

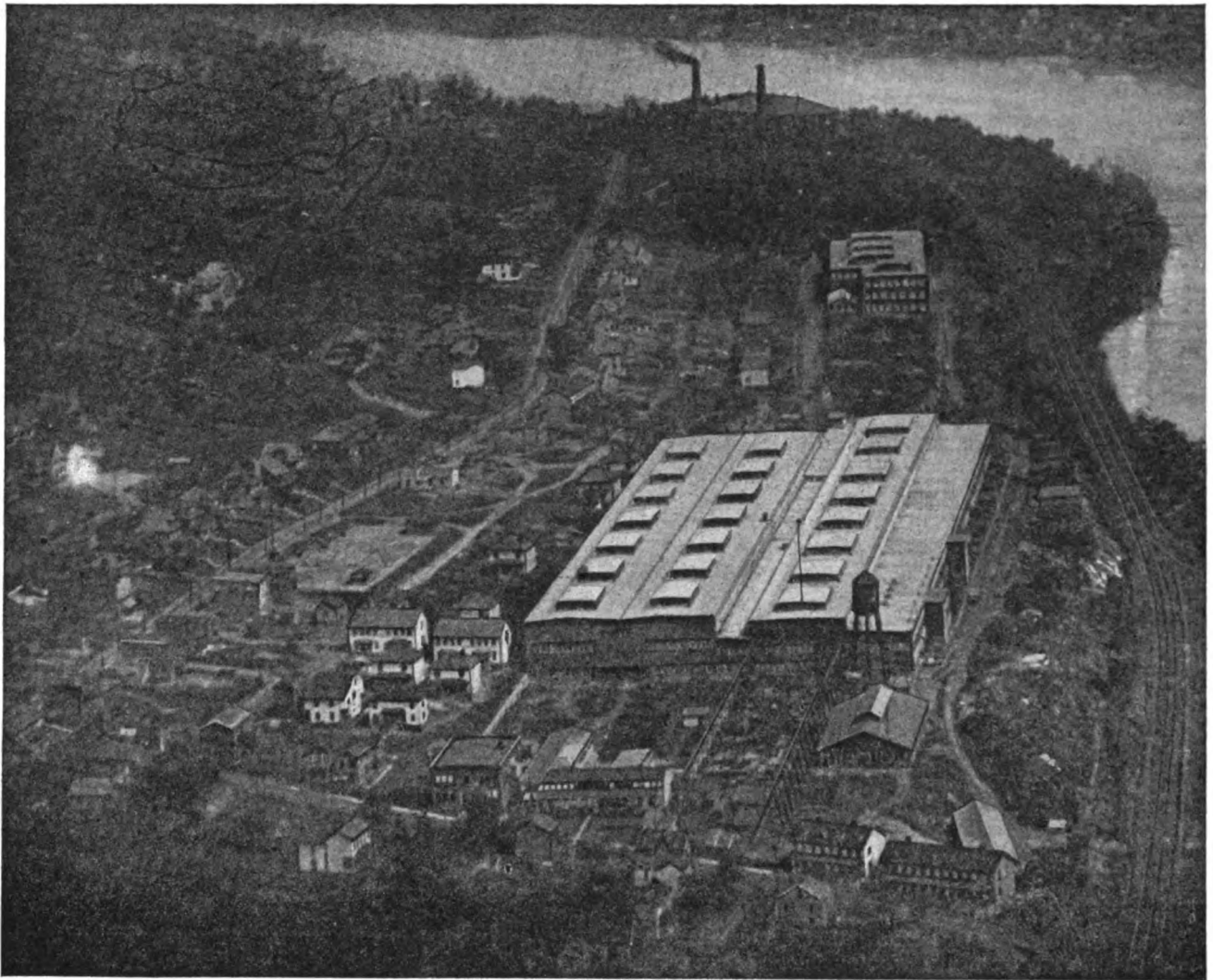


Fig. 2—Aeroplane view of the Blaw Knox Company plant.

duct is complete, it is sent to the test floor where it is subjected to pressure tests.

We now turn into the department where riveted plate work is produced. This department is equipped with presses, rolls, punches and other machinery for shaping the plates and they are finally riveted together in such products as accumulators, filters, flumes, steam pipes, gear guards and a thousand and one products which are either welded or riveted, or a combination of the two.

There are many containers, however, which, because of the character of their duty, must be so constructed that they can withstand extremes of expansion and contraction. This brings us to the forge and hammer weld plant, which is a separate building, devoted exclusively to the production of forge and hammer welded products which have a strength at the weld of from 90 to 95 per cent of the original plate.

The hammer weld shop includes equipment for forge and hammer welding, either mechanically or by hand, testing apparatus, generators for the manufacture of and containers for the storage of blue gas for

heating the steels, air compressors, boilers for generating steam and a motor generator for transforming alternating to direct current.

Hammer welding is a highly specialized process by which seamless, leakless products are manufactured from steel plates with a strength at the weld of from 90 to 95 per cent of the original plate and which can be subjected to the extremes in expansion and contraction.

The Blaw-Knox hammer welding plant is equipped to handle work up to 10 feet in diameter and 145 feet long, including such products as stills, condensor drums, high pressure tanks, steam jacketed kettles, digestors and many other containers used in the chemical field and allied industries.

There is still another large unit of the Blaw-Knox institution, located, not in Blawnox, but in Baltimore. This is the plant which produces prudential sectional, all-steel buildings, which are standardized in widths varying from 16 to 60 feet and can be built to any length. Space does not permit a description of the methods by which these buildings are made; this will be given in detail at some future date.

Selecting Proper Size Accumulators

A Method of Determining the Proper Size Accumulator for a Given Hydraulic System—Graphical Chart Shown Which Makes the Determination of the Proper Size Very Simple.

By R. W. SCHUETTE.

IN the contemplation of an hydraulic system, the sizes, strokes, and velocities of the various hydraulic cylinders are first determined to give a certain production, or to perform certain operations.

From this it is then known how often each cylinder must be used in a given time to produce the required results, and a maximum working cycle is practically determined.

The sum of the quantities of water used in each cylinder during this time will determine what minimum pump capacity is required.

Now, if the water consumption rate were exactly equal to the pumping rate, no accumulator storage capac-

pumping rate and to absorb the excess water when the pumping rate exceeds the consumption rate, is usually connected to the main hydraulic line.

The determination of the proper size accumulator becomes a simple matter by the following graphical method.

The time in seconds is plotted as the abscissas and water in gallons is plotted as ordinates. The first curve plotted is the water consumption of the individual cylinders in their proper rotation as determined from the operating cycle mentioned above. This is shown as curve (1) in the accompanying diagram.

The water consumption is plotted as straight lines, which assumes that the velocities of cylinder plungers and the corresponding consumption rates are constant. This is not exactly true because the velocity of the cylinder plungers will vary over the acceleration periods and the variable resistance of the work being done, but for all practical purposes it is accurate enough to use the above assumptions.

Curve (2) is then plotted as the cumulative curve of (1) or the total water consumption at the end of each ordinate of time in the cycle.

Curve (3) is next plotted. It is the cumulative pumping curve or total water pumped at the end of each ordinate of time, taking into consideration the efficiency of the pumps. It is plotted as a straight line which assumes that the pumping rate is constant. This is not true because in most cases reciprocating plunger pumps are used and the pumping rate varies with the plunger velocity. With a number of pumps in operation, these fluctuations decrease and from the nature of the assumptions in the operating cycle, and consumption rates, it is accurate enough for all practical purposes to assume that the pumping rate is constant. In other words, the plotted curves show ideal conditions.

Curve (4) drawn parallel to curve (3) passing through the highest point of curve (2) would show the ideal accumulator capacity as the ordinate between curves (3) and (4), but as ideal conditions cannot be had in practice, an allowance must be made and curve (4) is drawn somewhat higher than the highest point on curve (2).

Under the conditions assumed, the ordinates between curves (4) and (2) show the reserve water in the accumulator at any time during the cycle, or to another scale the movement of the accumulator from its lowest position.

Wherever curve (2) falls below curve (3), the pumps will run idle.

For a plant in operation the curves plotted in the reverse order will show what cycle must be followed in order to use existing equipment, or whether additional machines can be added without increasing pumping or accumulator capacities.

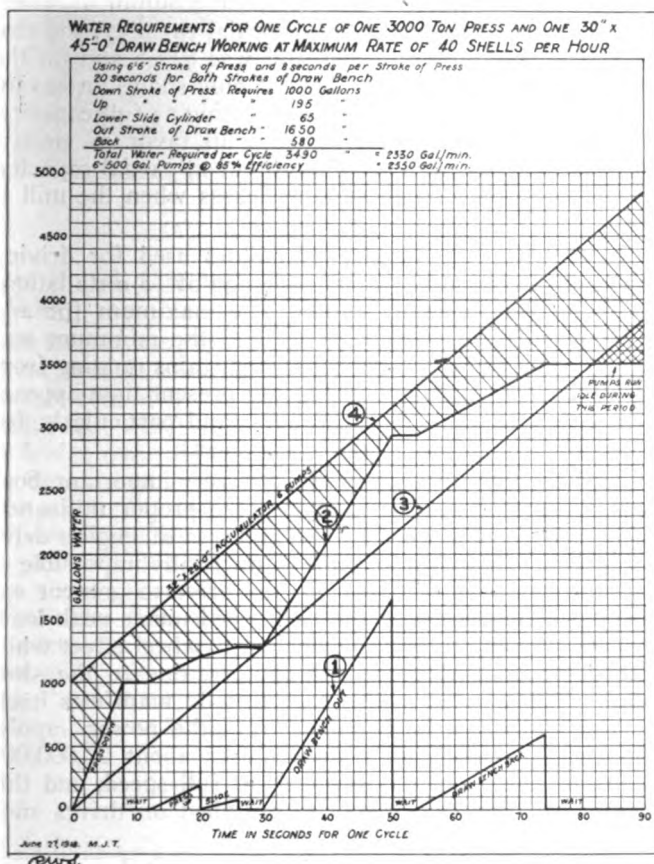


Fig. 1.

ity would be required and the pressure would vary with the resistance in the cylinders.

In practice, a constant pressure is desired and the water consumption rate varies considerably from the pumping rate.

To overcome these differences, a weight loaded accumulator, having sufficient volume to supply the excess water when the consumption rate is greater than the

Electrically Driven Sheet Mills

Figures Included Show That During the Pre-War Period the Cost of Power Per Ton of Sheet Produced on a Motor Driven Mill Was One-Half of That on the Engine Driven Mill.

By O. NEEDHAM,
General Engineer, Westinghouse Electric & Mfg. Co.

MODERN sheet mills are electrically driven, and in most cases the motor is geared to the rolls. There has been in the past considerable opposition to the use of gears for driving sheet mills, but this prejudice is dying out so that practically all new installations are using comparatively high speed motors and herringbone gear units. The chief criticism of gears has been that their use marks the sheet and makes an unsaleable product. However, an extensive use of gears on sheet mills demonstrates conclusively that there is no grounds for this complaint. The opponents of gear drives advocates the use of rope drives. The principle objection to rope drive, however, is its high maintenance cost and also the fact that it necessitates the use of a comparatively slow speed motor. The reason that a slow speed motor

pletely enclosed herring-bone gear unit with two flywheels overhung, one on each end of the pinion shaft. A flexible coupling is used between the motor and the pinion shaft to absorb shocks from the mill and protect the motor. The gear unit is provided with thrust collars on each side of the low speed shaft to protect the unit from end thrust caused by breaking spindles, rolls, etc.

The following figures on hot sheet rolling obtained from two mill trains operating side by side, one driven by a steam engine and the other by an electric motor will emphasize the advantage of electric drive. It was found that during the pre-war period the cost of power per ton of sheet produced on the motor driven mill was \$1 and that on the engine-driven mill was \$2. During the war period when the government limited the output of sheets and the mills were operating at partial capacity, the cost per ton on the motor driven mill was \$1.65 and on the engine driven mill \$4.45. This not only shows an advantage of the electric drive when operating at full capacity, but shows even a greater economy in favor of electric drive when operating intermittently or at partial capacity. This is due to the small standby losses when the mill is idle.

In checking up the size of motors used for driving sheet mills it is found that the average of 15 installations is 222 hp per finishing stand. The maximum for any single installation was 312½ hp and the minimum was 160 hp. The 15 installations included trains ranging from 4 to 10 mills. The tendency at the present time appears to be to install even more hp per stand particularly for rolling electric, or other high grade sheets.

The question of flywheel effect is very important, both as to the proper amount and also the proper utilization of the same. One of the disadvantages of engine drive is that, due to the slow speed it is practically impossible to get sufficient flywheel effect on the drive to prevent excessive slowing down of the mill speed under peak load. It is also difficult to install sufficient flywheel effect when rope drive is used even with motors, due to the slow speed. The trouble in this case usually manifests itself in very high peak loads taken from the power supply. The average eight mill train requires about 20,000,000 ft. lbs. of energy in the flywheels at full speed, and this amount can very practically be installed on drives such as shown in Figs. 1 and 2.

It is important that the flywheel effect be properly utilized otherwise its advantages will not be realized. Examples showing a graphic wattmeter curve taken on a sheet mill where a magnetic secondary controller using a fixed amount of slip resistance was used and one showing a graphic wattmeter curve taken on the same mill rolling the same schedule, but using an automatic liquid slip regulator to utilize the flywheel effect were recently compared. Reference to these two curves taken under identical conditions of rolling schedule and flywheel effect shows that in the case of magnetic secondary control peaks of 1600 kw are frequent, while with the auto-

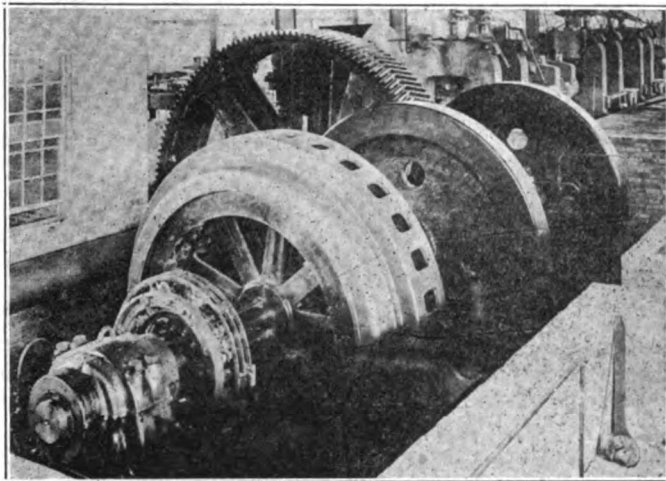


Fig. 1.

is required is that it is not practical to build rope sheaves larger than about 26 feet in diameter. It is also necessary for reasons of maintenance and economy to have the diameter of the smaller rope sheave at least 40 times the diameter of the rope. Two-inch ropes are used extensively for these rope drives and this will mean a motor sheave about 80 in. or 6 2/3 ft. in diameter, the ratio of motor speed to mill speed would therefore be 26 2/3 or 3.9 to 1. The average sheet mill speed is about 29 rpm, therefore, the motor speed would be about 113 rpm, and is usually somewhat less.

With modern herringbone gears there is no difficulty at all experienced in using ratios of 8 to 1 or even higher, so that motor speeds of twice the value given for rope drive can be used. This not only means a cheaper motor but means better performance, particularly as regards power factor.

Figs. 1 and 2 show the type of drive almost universally used at the present time for sheet mills. This consists of a motor running at about 240 rpm and a com-

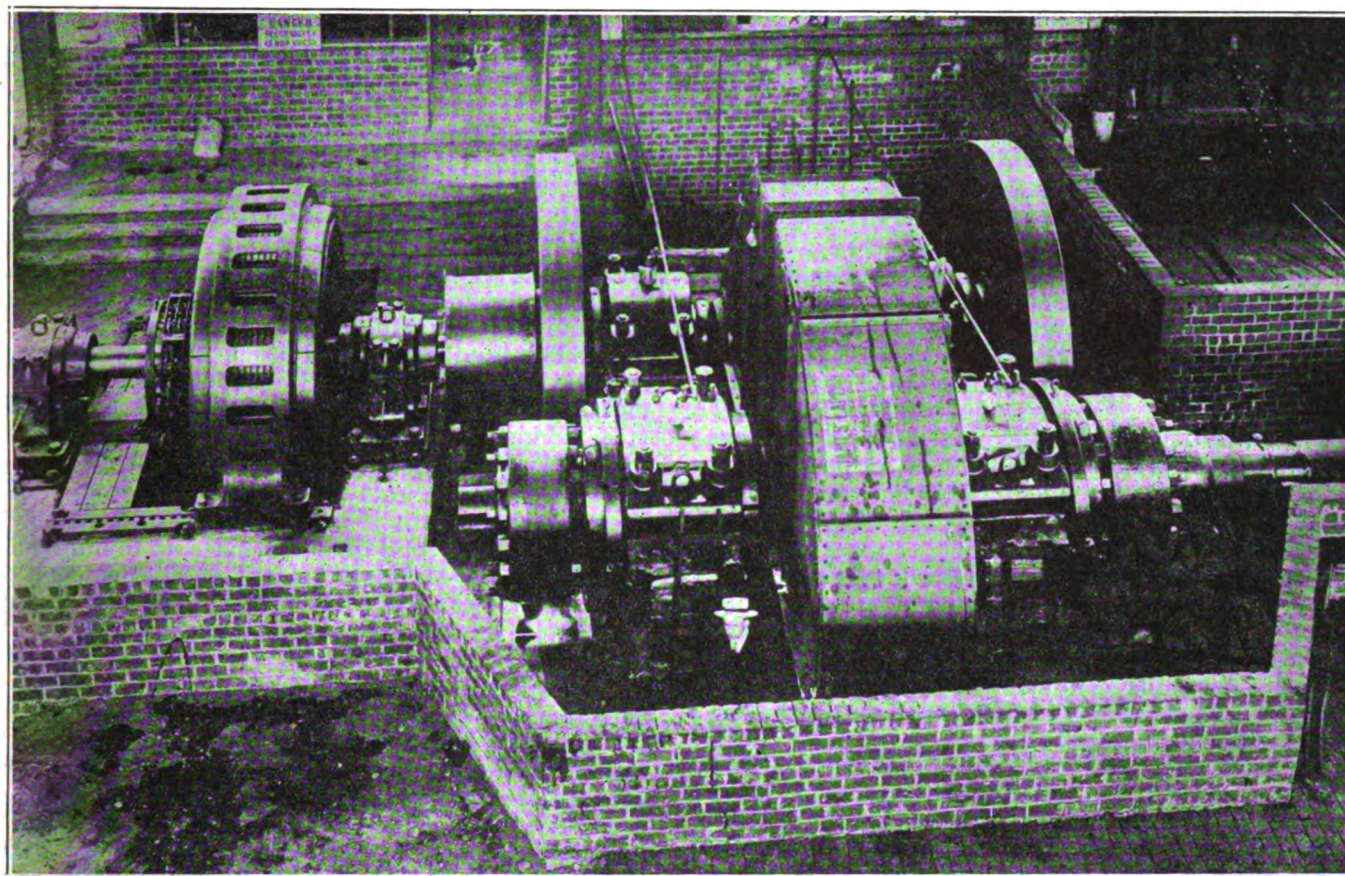


Fig. 2.

matic liquid slip regulator the peaks do not exceed 1200 kw.

Reference to Figs. 1 and 2 shows that the motor is located in close proximity to the mill, and is also in a pit. For this reason the ventilating air is heavily laden with metallic dust which tends to clog up the ventilating ducts and bridge over the creepage surfaces. It is desirable to provide some protection for these motors. This is sometimes accomplished by building a house over the motor and providing a blower to force air into the house. Openings are provided for the escape of air from the house, but a slight pressure is set up inside so that no mill dust enters. The main difficulty with this arrangement is that it is necessary to build the house low enough so that the crane will pass over it. It is also necessary to provide

a sectional roof so it can be lifted off in order to use the crane for working on the motor equipment.

A number of operators have overcome all of the above difficulties by simply adding enclosing covers to a standard motor and installing an air duct with blower to force air directly into the motor as shown by Fig. 3. In some cases where a source of clean air is not readily available an air washes has been installed. The amount of air required to ventilate a motor in this way is roughly about 10 cu. ft. per minute per hp rating of the motor. The blower motor is so interlocked with the main motor that the latter cannot be operated unless the blower motor is running.

The cold rolls require an average of 40 or 50 hp per stand under ordinary conditions. This value may be considerably exceeded, however, and may reach 65 or 70 hp for a few hours when starting up after a shutdown over the week-end, particularly in cold weather, when the grease on the roll necks becomes hard. The load on a cold roll mill is about 95 per cent friction and is therefore very steady so that no flywheel is required.

The delivery speed of cold sheet mills is about 230 ft. per minute as an average. Some, however, are as low as 215 ft. per minute and others run as high as 280 ft. per minute. It is advisable not to have the speed too high as it then becomes difficult to handle the material.

Motors for cold rolls are of the ordinary wound rotor type, constant speed. It is essential that these motors have a good starting torque in order to start the mill when it is cold.

A herring bone gear unit is used between the motor and the mill. The ratio is usually 10 or 12 to 1. Cold mills run about 33 rpm and the motor speed is usually within the range between 300 rpm and 375 rpm.

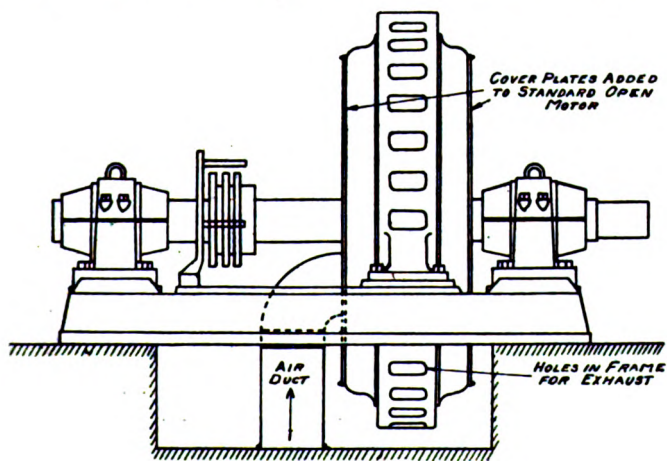


Fig. 3.

The Seamless Steel Tubing Industry

Development of This Industry the Most Rapid in the History of the Steel Business—Why and Economical Selection of Tubing Has Developed Almost to the Point of Being a Science.

THE seamless steel tubular industry has made substantial strides in recent years. Being a comparatively young branch of the steel industry its progress has been more noticeable than that of the more heavily established industries in the world of furnaces and rolls. The first use of seamless steel tubing in fairly large quantities was made at the time when the bicycle was at the height of its popularity; light, relatively thin gauge material being required for the frame—substantially the same as that required today for similar purposes.

The greater portion of this material, however, was not, at first, manufactured in this country from billet to finished product complete, but the rough hollow billets were imported and most of the so-called seamless steel tube mills confined their activities to re-rolling and cold-drawing these billets down to the required diameters and wall-thicknesses. The product thus produced was relatively high in cost, and as new uses were developed for the product, this factor must have been an obstacle to an immediate broader application of the material. But it was not long before the steel for seamless steel tubing was also being made in America, and this obstacle accordingly overcome. Another feature which may have retarded the development of the seamless steel tubular industry in the early years, was the necessity of producing tonnage, in contrast to the practice today of not only producing the product in large quantities, but producing it in such form as to require a minimum of re-working.

Designs in products which may have been held up because of prohibitive cost of machinery necessary for heavy forming, forging, boring and similar operations were made practical by the development of seamless steel tubing in a wide range of sizes, wall-thicknesses and shapes or sectional contours, and their manufacture from steels in different analyses to meet various requirements of strength, ductility, etc.

Thus the relatively heavy equipment of the seamless steel tube mill has taken the place of or made unnecessary much heavy machinery, excessive power, and large working forces at the point of fabrication or ultimate use.

The manufacture of cylinders for containing gases and liquids under high pressure has long been allied with the manufacture of seamless steel tubing, and as the operations required to manufacture these products either direct from flat plates or from seamless tubing are in the nature of heavy forging applications, it was but a logical procedure for the manufacturer to engage in the production of other forged specialties whose designs were essentially tubular. In this class, we find as forming a large tonnage output, such products as axle housings, cupped parts, tubular shafting (flanged for connections, tapered, etc.), cream separator bowls, motor cylinders and similar products, some being used just as they come from the tube mill and others requiring light finishing operations at point of assembly or sale.

In more recent years much material of this kind has been required by the intensive development of the

automotive industries, although there had long been a heavy demand for seamless material suitable for ball and roller bearings, axles and similar heavy requirements and this has resulted not only in an increase of manufacturing facilities but marked improvement in the handling and manufacture of seamless steel tubing and the material from which it is made.

Due to the adoption of heavy piercing machinery, the sizes manufactured of seamless steel tubing have been increased until it is possible to secure this material made from solid billets, in sizes up to nine inches in diameter, as compared to four or five inches a few years ago. Seamless steel tubing, made by cupping flat plates, however, is made in diameters up to 20 inches.

A tendency which is important enough to be remarked upon in passing, is that of the consumers of tubing (especially of the heavier grades), to use the class of material known as hot rolled or hot finished in increasing preference to cold drawn tubing—sizes, properties, etc., all being equal. This may be accounted for in several ways, each peculiar to the nature of the product for which the tubing is used, or by manufacturing conditions which make it more expeditious and economical to do slight machining in the shop rather than depend upon the finishing or accuracies obtained in the cold drawing process in the tube mill. It has been argued by some that cold drawing of tubes produces lines of strain in the material, but this may be discounted by the fact that it is necessary to remove and such strains by thorough annealing before a tube can be successfully cold drawn, and after the final drawing the tubes are invariably given an anneal with this object in view or to draw them down to some degree of anneal required for machining or forming operations. Everything else being equal, it would seem therefore that the principal cause of the increase in the use of hot rolled tubing is the elimination of an operation in manufacture which is often and rightly considered as unnecessary.

Where the tubing must come within very close requirements as to gauge and diameter owing to the fact that it is to be applied or used without further machining, the cold drawing operation is indispensable. It is also possible that manufacturers have found that requirements in certain uses for tubing were unnecessarily close and this would logically result in an increased use of hot rolled or hot finished material. It may even be further assumed that the increase in the use of hot rolled tubing has not been greater because of the fact that it is not mechanically possible to produce the hot rolled product in sizes smaller than 1½ to 2 inches in diameter.

The figures given by the American Iron and Steel Institute* for hot finished material alone, are, 1916, 61,235 tons; 1917, 87,615 tons; 1918, 142,306 tons; 1919, 75,864 tons; the tonnage of hot finished tubes produced in 1919 representing a normal increase over

*See Special Statistical Bulletin No. 4, 1920, of the American Iron and Steel Institute.

1916 of 14,629 tons. The corresponding decrease in production of cold drawn tubes is 7,733 tons, the figures for this material in 1919 being 121,505 tons, and those in 1916 being 129,238 tons.

The total production of seamless steel tubes in the United States in 1919 was 197,369 tons; this represents a normal total increase of 6,896 tons over the production of 1916; the relatively heavy production of 1917 and 1918 being due in some measure to the large tonnage of seamless material required for munitions in the shape of cylinders and specially formed articles. The tonnage of seamless steel tubes for 1917 was 226,675, and that for 1918 was 292,694; these figures exceeding by 89,736 tons, the total production of welded iron pipe and boiler tubes for 1918.

The outstanding feature of interest in the seamless steel tube industry in recent years is the development of what may be termed the versatility of the

product. This has long been noticeable in various other lines of industry, where the products manufactured were of more general applicability. The mechanical development of this country however made it necessary to manufacture tubing in a range which is as great as many other basic materials, and greater than some.

In those forms of machine design where the very life of an organization depends upon continual improvement or intensive development, the ever present question of the designer or engineer has been: "Where can I find a material heavy, light, strong, stiff, hard, or ductile enough to meet this need or that requirement?" and the manufacturers of seamless steel tubing have answered the question time after time by having developed a very flexible range in this product.

(Continued in February issue)

Recent Developments in Electric Mill Drive

Practically All New Reversing Mills Built During 1920 Are Electrically Driven Mills—Most Interesting Reversing Mill Drive of the Year Built for Tata Iron & Steel Co. at Temshedpur, India:

DURING 1920 the use of electricity in the steel industry has continued to increase. Almost without exception new equipment has been motor driven. In the past the greatest competition between the steam engine and the electric motor has been on main roll drive and particularly on reversing mill. The seven slow speed motors of 6,000 hp and over, installed between 1908 and 1911, which have been in successful operation at the Gary plant of the Illinois Steel Company for so many years, proved conclusively that the electric motor could be made to stand the severe duty of driving the largest mills, giving increased reliability and decreased upkeep, very materially reduced cost per ton of rolling steel, and at the same time, an increased number of tons rolled per month over anything considered possible with steam drive—largely due to the remarkable continuity of operation. Since this epoch making installation, there have been very few large steam engines applied to non-reversing mills and, in the last year or two, none at all, but there have been many instances of motors replacing engines on old mills.

For non-reversing mill drive, the high inertia of the large slow speed induction motor was an advantage, as the engine had to be provided with a flywheel to obtain more uniform speed. For reversing mill drive, however, the reciprocating engine possessed the advantage, due to its smaller inertia compared to the direct current motor. The decision, however, was again in favor of the motor, and in the last few years there has been only one notable new steam engine installation, and in this case, a combination of very unusual circumstances made the first cost of the engine drive very much less than the motor but, even with this handicap, over a term of years, the cost per ton of steel rolled would be less with the motor, on account of its slight upkeep and the fewer number of shutdowns and delays chargeable to the motor.

Considering a mill driven first by steam engine and then by dc reversing motor with a flywheel motor-generator supplied with power from a turbo-alternator, we find the engine drive will require at least double the boiler capacity. The mill will require peak loads of say 20,000 hp from either the engine or the motor, but with the engine, this sudden demand for steam will be thrown back directly on the boiler, which must be of ample size to prevent drop in steam pressure and sludging. Also at this peak load the engine will operate at full cutoff, and whether discharging to atmosphere or condensing, require enormous quantities of steam per hp hour, compared to that required for a steady load near the engine rating. With motor drive the slip regulator on the induction motor of the flywheel motor generator would maintain a practically constant demand on the turbine generator of approximately 6,000 hp, and the demand on the boiler plant would be only the steam required by a high efficiency turbine operating at comparatively steady load and delivering a maximum of 6,000 hp. During the peak loads the induction motor of the motor generator will supply 6,000 hp and the flywheel will furnish the additional 14,000 hp by slowing down and giving up its stored energy. When the load drops off, the induction motor will continue to supply 6,000 hp which is stored up in the flywheel until the wheel is brought back up to speed. Also, when the main mill motor is stopped the energy used to accelerate the motor armature is returned to the flywheel, so this energy is recovered on each reversal and has very little effect on the power demanded from the ac line—merely the losses incurred in transforming this energy from mechanical to electrical and vice versa.

In the last analysis, however, it is tonnage output of the mill in which the mill owner is interested, even more than cost per ton of rolling, and in this last year the electric mill has definitely proven itself at least the equal of the best steam mills, under conditions favorable to the

latter. The mere statement that a certain mill rolled 50,000 tons in a month means little, as the product of the elongation and tons is the measure of the work done and even then it is necessary to take into consideration the initial weight and dimensions of the ingot, for with small ingots there is more lost time in intervals and reversals, and the average rolling speed is less than with larger ingots, due to the shorter lengths not giving room to accelerate to and retard from high speeds. When all these factors are taken into consideration, the 36 in. mill of the Trumbull Steel Company at Warren, O., and the 40 in. mill at the Sparrow's Point plant of the Bethlehem Steel Company, are more than the equal of the fastest steam mills. The latter mill recently ran approximately 64,000 tons of ingots in one month, rolling principally 21x23 inch ingots to 8x8 inch blooms and 21x43 inch ingots to 6x38 inch slabs. The 7,000 hp continuous A. I. E. E. rated motor on the 45 inch bloomer at the Fairfield plant of the Tennessee Coal, Iron & Railroad Co., with its 22,000 hp momentary capacity at 50 rpm, is capable of greater output than either of the installations referred to above, but it has never been supplied with steel fast enough to ascertain what it can do.

The enormous output of these electric mills is due to the use of reversing motors and generators which give a constant speed for any controller position, regardless of load, and to having the current limit set high enough to pull through any normal pass without causing the limit to function. It is essential that the current limit be set at the guaranteed maximum of the equipment, as otherwise the motor cannot accelerate at the guaranteed rate on normal passes, for only the difference between the torque required for rolling and the torque corresponding to the current limit setting is available for acceleration. In the limiting case where the torque required for rolling is equal to that corresponding to the current limit setting, it is impossible for the motor to accelerate and the pass must be rolled at entrance speed.

High speed graphic time-speed curves of such equipments show the mill motor is retarding from 90 rpm to rest in approximately one second, and accelerating from rest to 90 rpm in approximately two seconds, and is making the complete reversal from 90 rpm forward to 90 rpm reversed in three seconds. This speed of acceleration and retardation with shunt wound machines is independent of whether or not there is metal in the rolls, as the speed of the motor must follow the generator voltage, and unless the current limit operates, the rate of change of this voltage is determined solely by the time constant of the generator field, which in turn, is fixed by the ratio of inductance to resistance in the field circuit and, therefore, in a fully compensated machine, is not affected by the load. Obviously this is not the case with compound wound motors and differentially wound generators. This high rate of retardation is of great value in cases of emergency, such as cobbles, and in ordinary rolling the quick stop allows the maximum speed to be maintained till very near the end of the ingot, thus increasing the average speed of rolling. In the same way, a high rate of acceleration increases the average speed and the tonnage output of the mill, and for these reasons is desirable even if the time to reverse from delivery speed in one direction to entrance speed in the other is less than that required to adjust the screw down.

An interesting reversing mill drive built in 1920 is that for the 40 in. blooming mill of the Tata Iron & Steel Co. at Sakchi, India. Power is taken from a 3,000 volt, 50 cycle, 3 phase line by a 5,000 hp (A.I.E.E. rating), 375

TWENTY-ONE—BLAST

BARN
rpm, slip ring type induction motor which is part of a four unit six bearing flywheel motor generator. The flywheel is of special grade cast steel weighing a little over 100,000 pounds and having at maximum speed a stored energy of 130,000 hp seconds. The three generators are duplicates, each being 2,700 kw (A.I.E.E. rating), 600 volts, shunt wound, giving a total normal generator capacity of 8,100 kw. The power input to the motor generator is controlled by a three phase slip regulator connected across the slip rings of the induction motor and operated by a torque motor, which varies the secondary resistance so as to maintain a constant current input to the induction motor whenever the flywheel is below its normal speed.

The main mill motor is a double unit consisting of two 3500 hp (A.I.E.E. rating) 55/120 rpm 900 volt shunt wound machines forming a 7,000 hp unit, and is guaranteed to develop momentarily 22,000 hp at 50 rpm and 17,000 hp at 120 rpm without injury, and the current limit will be set at these values.

The armature circuit consists of the three generators and two motors connected alternately, so that by grounding between the two generators which are not separated by a motor, the maximum voltage to ground at any point on the circuit will be 600 volts. The machines, however, are insulated for 1,800 volts.

Excitation is derived from a 150 kw 250 volt motor generator, the two motor fields being in series across 250 volts and the three generator fields in series. Speeds from 55 rpm forward to 55 rpm reverse are obtained by varying the strength and direction of the generator shunt field by means of contactors controlled by the master switch, the motor field being constant at its maximum value throughout this range. Speeds from 55 rpm to 120 rpm in either direction of rotation are obtained by varying the strength of the motor field, the generator field being constant at its maximum value. The entire control is by means of a single lever which operates the motor driven master switch.

The equipment has a guaranteed torque of 2,310,000 pounds at one foot radius and is the most powerful built in the United States, with the single exception of the drive for the 45 in. blooming mill at the Fairfield plant of the Tennessee Coal, Iron & Railroad Co., which is very similar to the Tata machines and has approximately the same guarantees.

FALCON STEEL COMPANY INSTALLATIONS.

The Falcon Steel Company is installing a galvanizing department at its sheet mill plant in Niles, Ohio, which will be ready for operation by the first of the year. The addition will contain three galvanizing pots. Heretofore the bulk of its production has been black and blue annealed sheets. The company operates six sheet mills and two jobbing mills. Plans have been completed to double existing capacity, but the date when work will start is indefinite owing to certain business conditions. It had been originally planned to commence the extensions next spring. Lloyd Booth, formerly treasurer of the Trumbull Steel Company, at Warren, Ohio, is president of Falcon Steel Company, while Paul Wick, formerly in the sales department of the Trumbull company, is general manager.

Modern Rolling of Special Beams

Progress Has Been Made in Getting Perfectly Formed Beams
New Mills Describe Which Are Overcoming the Many Difficulties
Encountered by Operators—The Grey Mill Is a Foremost Example.

By F. J. DENK.

WONDERFUL progress has been made in the last few years in regard to the rolling of wide flanged, parallel faced beams.

The standard beam section rolled in the ordinary shape mills are subject to a number of disadvantages. Pre-eminent among these disadvantages is the limitation in the width of the flanges and in the thickness of the web. In the ordinary beam mill, flanges and web are rolled in a closed groove, the web being the only part of the shape, that is actually rolled upon, while the flanges are formed by crowding the metal into and through the flange grooves. This condition

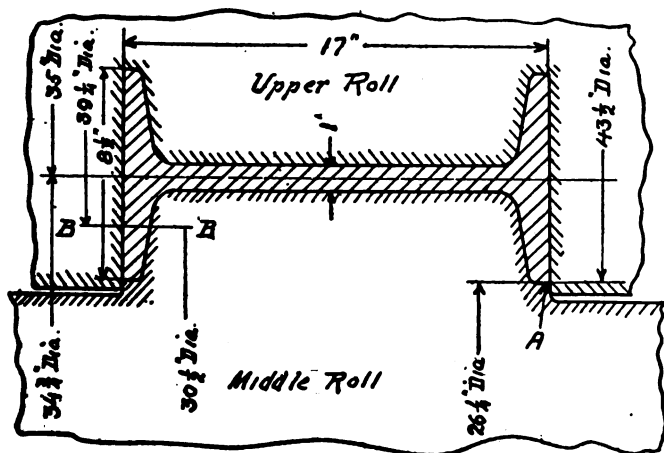


Fig. 1.

naturally limits the size of the flanges. The web, on the other hand, cannot be rolled below a certain thickness; for this reason the web, in general, is thicker than necessary for structural purposes, and this means a waste of material. Another disadvantage lies in the fact, that the I-beams, rolled in the ordinary way, show, especially in the large sizes, a great variation in the quality of the material between the web and the flanges. This is due to the difference in the work of reduction of the metal during the rolling process, which difference is caused by the difference in speed of the various points of the groove, located opposite each other on the two rolls. The results are unequal internal stresses, which may, under certain conditions, cause a splitting of the beam.

This difference in speed can easily be seen from Fig. 1, which represents an intermediate groove in a 35-inch, three-high beam mill, rolling 18-inch I-beams. The diameter of the middle roll at point A is 26.25 inches, while the diameter for the same point on the upper roll is 43.5 inches. The circumferential speed is correspondingly 6.87 and 11.39 feet per revolution or the speed of the upper roll for point A is 1.66 times as large as the speed of point A on the middle roll. Similarly, at section B-, the speed of the top roll is 1.29 times that of the middle roll. That such difference in the circumferential speed have a decided in-

fluence on the quality of the metal, is self evident. For this reason, the design and layout of such grooves must be made with the utmost care, so that splitting or cracking of the beam, due to internal stresses, may be avoided.

A further disadvantage is to be found in the low moments of inertia and section modulus, referred to the vertical neutral axis. This, of course, is due to the proportionally small width of the flanges, which, in turn, is caused by the conditions specified above.

Lastly, all standard shapes must be designed with a certain slope on the inside of the flanges, in order to facilitate rolling in the closed grooves. This slope is 16.66 per cent for all standard shapes used in the United States, and makes difficult screwing or riveting of a branch of the main beam.

To overcome these difficulties, a number of types of mills have been designed in the course of the years, but of all those designs only four have stood the test and are in use today. Those four are:

1. The Slick mill, for rolling small sizes of mine timbers etc., up to 10 inches; 2, Grey mills; 3, the Sack mill; and 4, the Puppe mill.

All the other types have either disappeared from the market or they have not been built at all, remaining on the paper only. The reason for this condition, or at least one of the reasons, may be due to the fact that the design of the cross sectional area of shapes is influenced not only by considerations in regard to the economy and strength, but also by conditions which guarantee sound metal at the intersection of the web with the flanges. Naturally, an unsatisfactory design will set up at these places considerable internal stresses due to rolling, which, in connection with longitudinal shearing stresses, caused by the imposed load, will considerably decrease the carrying capacity of the beams.

Leaving out of consideration the Slick mill, the oldest type of mill for rolling wide flanged beams is the Grey mill at Differdingen, Luxemburg, which was erected in 1902. After this mill has been successfully operated for several years, the Bethlehem Steel Company decided to erect one of the same type at South Bethlehem, Pa. Rolling was started early in 1908 and also proved successful. The difference between the Differdingen and the Bethlehem sections is due to the slope of the inner faces. While the former ones have a uniform slope of 9 per cent, the latter ones have only 2 per cent. The Bethlehem mill is composed of one reversing blooming mill, one intermediate mill and one finishing mill. In the reversing mill the ingot of ordinary size is rolled down to a rough I-beam shape, while ingots for large beams are cast in an approximately I-beam shape and then rolled down to the desired section. From the blooming mill the ingot goes into the intermediate mill, which is a universal mill. Instead of the horizontal grooved rolls of the ordinary beam mill, this universal mill has separate horizontal and vertical rolls, which form the web and the flanges

by coincident rolling operations. In the finishing mill the flanges are edged only.

The advantages of shapes rolled in the Grey mill over those rolled in an ordinary beam mill are due to the following conditions:

1. The working of flanges and web independently from each other causes a greater uniformity of the material, and, therefore, greater uniformity in strength.
2. The flanges of Grey beams can be made wider than the flanges on I-beams rolled in an ordinary mill, which results in a higher moment of inertia and a higher section modulus, referred to the vertical neutral axis; in favor of the Grey beam.
3. The slope is reduced to 9 per cent on girders and beams and to 2 per cent on H-beams. This, of course, is a big advantage over a slope of 16.66 per cent on standard sections, but it makes still difficult the connection of branches by means of bolts or rivets.

The second type of a mill for rolling wide flanged beams, is the Sack mill, which turns out beams with entirely parallel faces. The first mill of this type was erected in 1907 at Rombach, Germany. The installation consists of a standard two or three-high mill, a universal roughing mill and a universal finishing mill. The rough section is produced in the two-high or

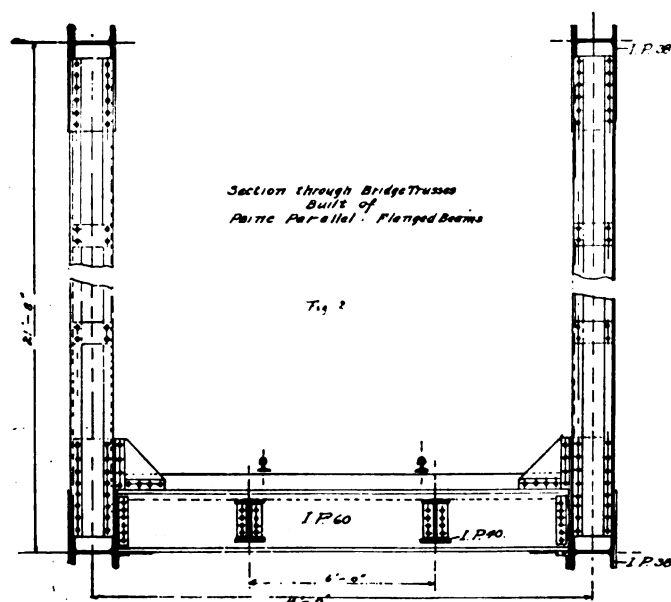


Fig. 2.

three-high blooming mill, where a rough I-shape is rolled. This blooming mill is fitted with rolls of 34 to 36 inches diameter, 9 feet to 9 feet 8 inches long. The highest section rolled at present is 22 inches. The universal roughing mill is a quadruple mill, having four rolls, two horizontal ones and two vertical ones, which all lie in the same plane.

The universal finishing mill is also a quadruple mill, with two horizontal and two vertical rolls, all arranged in one plane. This mill is merely a polishing mill and it requires, for this reason, no appreciable adjustment of the rolls. A detailed description of this mill can be found in the August, 1920, issue of this magazine, to which the reader may be referred.

The last mill for rolling wide flanged beams is that designed by Dr. Puppe, and built at Peine, Germany. As originally calibrated, the sections had flange-faces, which were parallel up to a certain distance from the web, from there on there was a slope of 10 per cent. Recently the faces are rolled parallel all through, the

sections having, therefore, the same shapes as those rolled in the Sack mill.

The Puppe mill consists of a roughing blooming mill and two universal quadruple stands, each one with two sets of rolls, the corresponding roll-sets lying in one plane. The universal stands are located close together.

The process of rolling is such, that the beam blank comes from the blooming mill in the shape of a thick walled H. It enters the roughing stand, where both web and flanges are worked upon, while the bloom has a double Y-shape. From the rougher the bloom is going forward and backward through the finishing mill. In the first pass of this mill, i. e., during the forward movement of the beam, the flanges are straightened by means of the vertical rolls, while in the second pass, i. e., during the backward movement of the beam through the same rolls, the edges are worked upon. The piece is then sent again through the rougher, where the flanges are bent back to the double Y-shape. The beam or girder is rolled down to its final size by continuously going back and forth through the roughing and finishing rolls until the final section is obtained.

By means of this method, the metal is worked upon and kneaded thoroughly; it allows to roll beams or girders with almost any width of flanges; it, furthermore, makes possible the rolling of flanges with absolutely parallel faces.

The original Puppe section had been designed with a slope of 10 per cent between web and flanges, in order to insure a smooth connection between these two parts. This sloped piece, however, is so short compared with the total width of the beam, that there is enough space left for the parallel part, for making connections, by means of rivets or bolts, to plates and angles.

The present Peine sections, rolled with the same mill, have entirely parallel faces like the Sack beams.

The first Puppe mill started to operate in the fall of 1914 and has been working since that time to the satisfaction of all concerned. The largest size rolled up to the present time is 24 inches. For beams from 6 to 12 inches, approximately, regular ingots of 3.3 to 3.8 tons weight are used, whereas for the higher sections above 16-inch ingots cast in a rough H-shape of 8 tons weight are used. In the blooming mill 21 passes are necessary for sections up to 12 inches, 35 passes for medium sized sections and 27 to 31 passes for the large sections. The number of passes in the finishing stand varies between 9 and 15, according to the size of the finished product.

The length of the blooming mill rolls is 9 feet 2 inches, with a diameter of 4 feet and a weight of 26 tons. The capacity of the mill is 400 to 450 gross tons of 12" x 12" H-beams in 8 hours.

The field of application of wide flanged parallel faced beams is a very extended one. They may be used as columns or posts for office or factory buildings, for tipples, railroad viaducts, elevated roads and underground railroad. They may also be applied for main bearing members and cross connections in all kinds of buildings, bridges, viaducts, etc. They are useful as cross-ties for railroad yard, wharf tracks and as mine timbers and for mine railroad tracks. In many cases such beams can be used successfully in place of built-up or riveted plate girders, on account of their higher moments of resistance. Such a pro-

(Continued on page 102)

Steel Foundry Department



The Side Blow Converter Foundry

The Logic of Roll Design

By W. H. MELANEY.

The Side-Blow Converter Foundry

A Modern Method of Making Steel Castings—Over One Hundred Steel Foundries Now Using Side Blow Converters—General Layout of a Modern Shop Shown.

By G. P. FISHER,
Whiting Foundry Equipment Company.

THE Side-blow Converter is in operation in about 100 steel foundries in the United States. It is used mostly for the manufacture of small castings of very light section and for intricate shapes, competing with the electric furnace in this respect. Possibly the greatest advantages the converter has over all processes is its great flexibility, ease of operation and small initial

investment. It can be put in operation on an hour's notice and can produce 20 heats per day or only two or three at practically the same cost per heat. Heats are usually blown from 12 to 15 minutes each. When not in operation it requires no attention and the only costs against an idle converter are depreciation and interest on investment, both of which are negligible. The heats are small and produced at short intervals which permits floor space to be used over several times during the day.

The usual charge in converter practice consists of 40 to 50 per cent pig iron and 50 to 60 per cent steel scrap, although the author has seen a converter operated on the use of 100 per cent steel scrap. On account of the converter being operated with an acid lining, raw materials having a low phosphorus and sulphur content must be purchased.

Many plants operating an iron foundry have a demand for steel castings. Where this demand is intermittent and not for a large tonnage, the converter is the ideal installation. The melting equipment for the grey-iron foundry and for the converter steel foundry is the cupola, already installed. When steel is required the metal can be melted in the same cupola ahead of the grey-iron mixture. Where small tonnage is to be had the initial investment is worthy of serious consideration. The converter can be installed and put into operation for approximately one-sixth the cost of the electric furnace and from one-half to one-third the cost of open hearth.

Another very important factor is the ease of operation, it is unnecessary to employ a high-priced furnace operator who will be of little or no use when there is no demand for steel. The foundry foreman or any intelligent employee can be trained in a very few weeks to operate and produce good steel. If only two or three tons of castings are required per day the time neces-

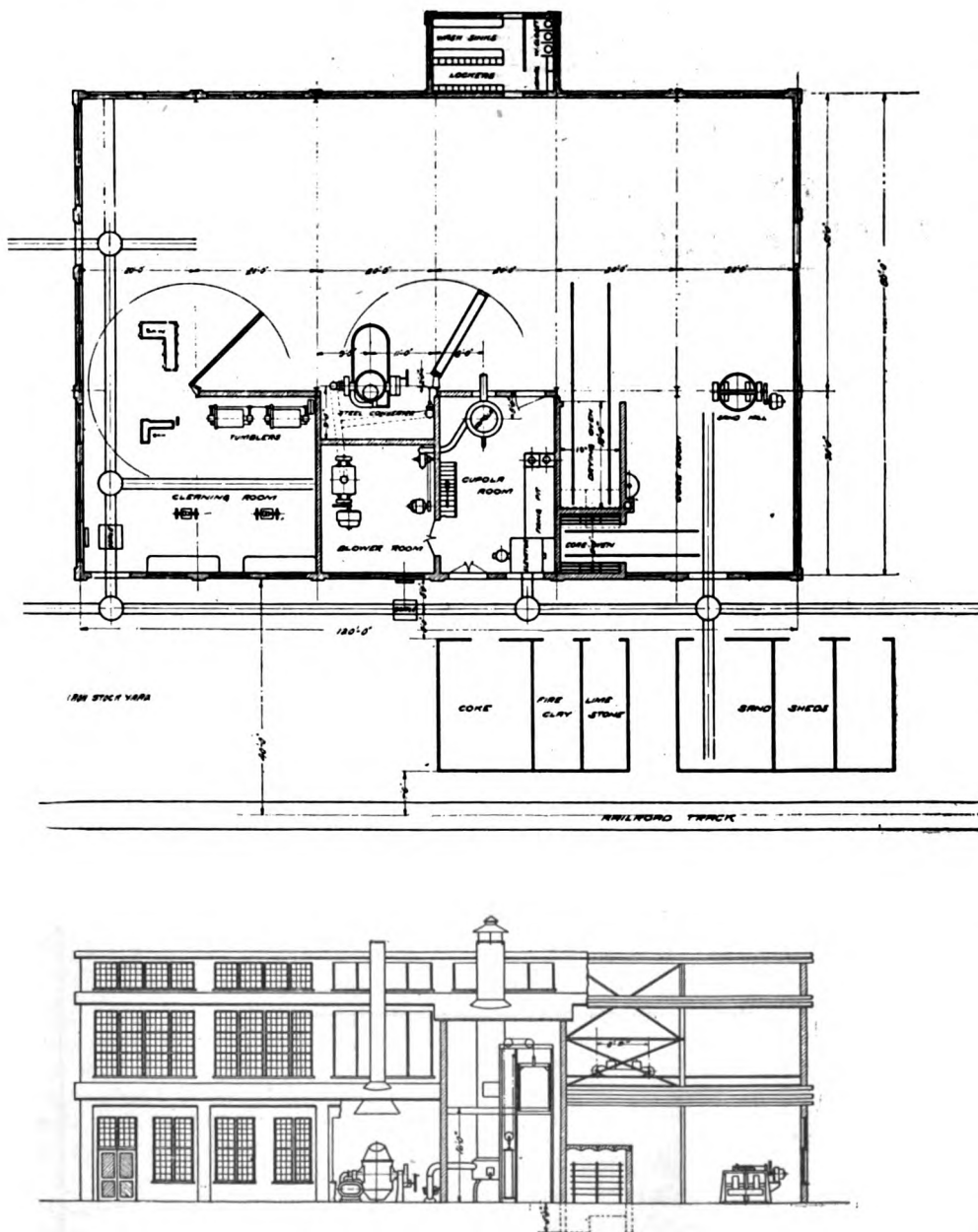


Fig. 1—Shows typical arrangement for a converter steel foundry, the cupola and converter steel foundry, the cupola and converter close together. Metal from the cupola to converter handled by means of jib crane. The entire main bay being used for moulding, the cleaning department at one end of layout.

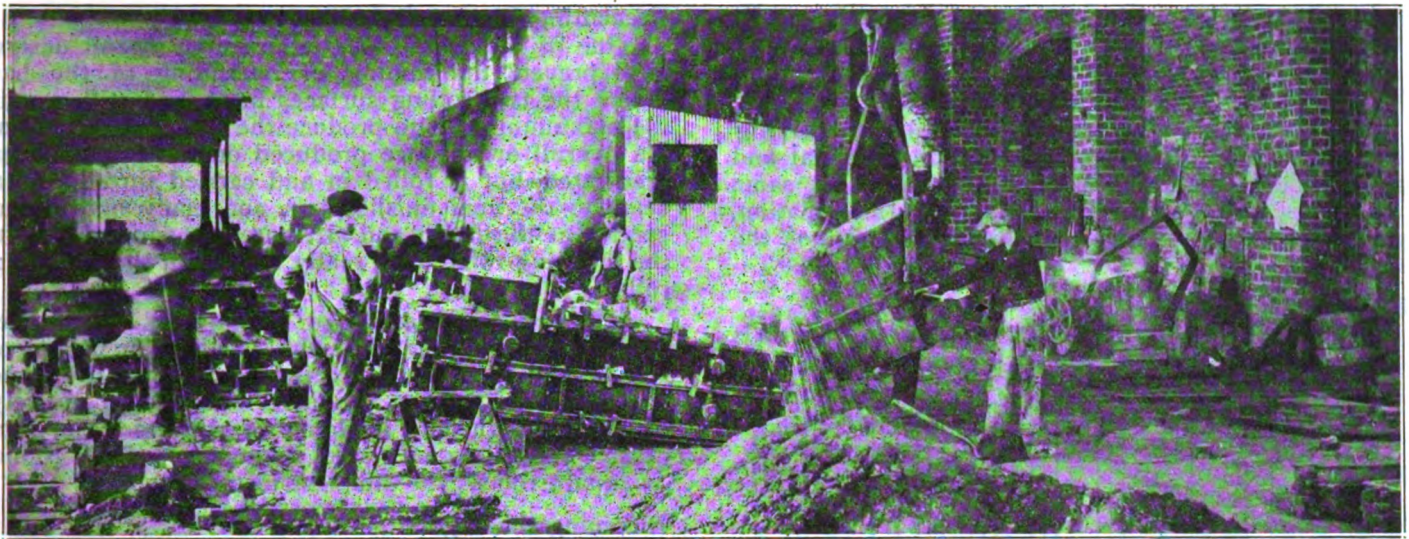


Fig. 2—Shows the steel being poured into moulds by the use of a tea pot spout ladle. This type of ladle gives very clean metal as all metal comes from bottom ladle; it is similar to the "bottom tap" in this respect.

sary to blow steel will take only a small part of the foreman's time and will interfere with his regular duties to a very small extent. While it is possible to pour a casting weighing several tons by the accumulation of two or three heats the converter finds its greatest application in the manufacture of small and very light-section castings.

The moulding practice in a side-blow converter plant

is the same as in all other steel foundries, a good bond silica sand being used.

Castings should be annealed to remove strains, and any alloy steel be properly heat-treated in an oil-fired annealing furnace. The cleaning equipment consists of tumblers, sandblast machines, grinders and an acetylene outfit for burning off of gates and risers.

The Logic of Roll Design

Discussion Showing the Method of Reducing Steel From the Ingot to a Round or Square Rod of Small Section—
Prevention of Fins and Overfill.

By W. H. MELANEY.

PART I.

OF all the important sciences in universal use, that of the deformation of metal by the rolling process, seems to be the least understood by those not actually concerned in roll design, and even many of these do not seem to grasp the real reason why certain well established rules are followed.

The deformation of steel by rolling is governed by the same principle that holds true in electricity. That

If as many seem to suppose that forming steel into various shapes by rolling, was simply a matter of the shape of the groove and the amount of reduction, then it would be a simple matter indeed. But such is not the case as many a roll designer can testify, after he has had some favorite design turn out a miserable failure, so far as making a perfect section is concerned.

Designing a groove and then compelling the hot steel to fill up that groove, even though the metal entered into it is amply sufficient therefor, is two very different things, and sometimes the most unexpected results are obtained due to faulty reasoning by the designer. A groove may over fill in some unexpected and undesirable place and fail to fill up in some other place where a full section is required.

This has resulted in much conjecture as to why this happens and in many instances two persons, each supposed to be equally skilled in the art, will assign a different reason for the happening and a great deal of mystery has been woven about roll designing, where there should be no mystery.

No matter what result is obtained, in trying out a new design of rolls to produce a given section, one thing can be definitely decided on, and that is that there is a good practical reason why this result was

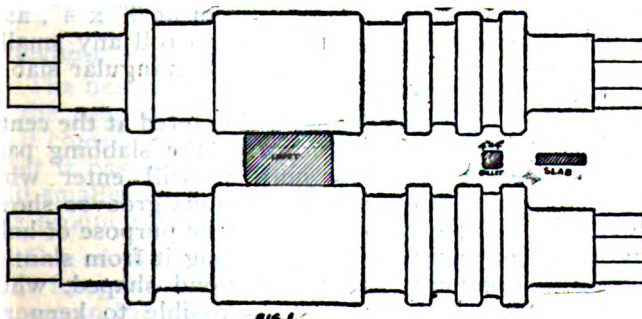


Fig. 1—Standard two high blooming mill rolls.

is, the flow of the steel under pressure, like the electric current, follows the path of least resistance, and this has given rise to many unlooked for and unexpected happenings.

obtained, and that under absolutely the same conditions this same result will always be obtained. Therefore, there is no mystery about it, for if there were definite results could not be depended upon.

It is true of course that a set of rolls for making a given section will work perfectly on one trial and later on fail under what seems to be exactly the same conditions, but after carefully analyzing the situation, you will invariably find the conditions are not the same.

Effect of Heating Steel.

If a piece of metal is heated very hot so that it is soft and plastic and then rolled through a pair of rolls,

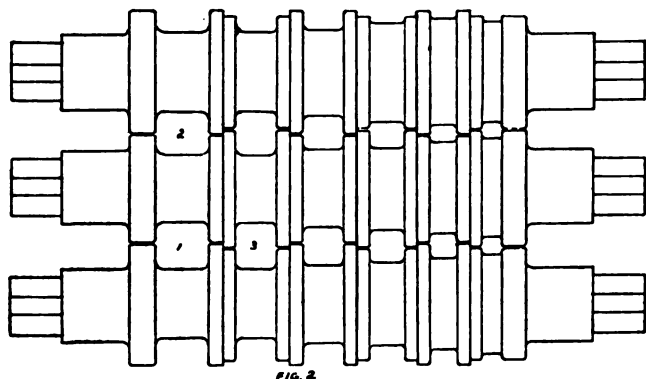


Fig. 2—Positive pass three high blooming mill rolls.

it will offer very little resistance to elongation, and consequently will spread very little in the process, the reduction going almost entirely into elongation. On the other hand, if the metal is poorly heated and not soft clear through, or if it is harder from any other cause, the extra resistance will cause a little more spread and a little less elongation.

This is shown conclusively when rolling long rods, where sometimes the first end of rod will be slightly underfilled, the middle just nicely filled, and the last end, due to cooling, will be slightly overfilled, because the colder the rod became the more it spread. Or perhaps one bar may be nicely filled and the next one overfilled, because the overfilled bar was finished at a lower temperature or was of a slightly higher carbon, and therefore spread more.

This is also one of the reasons why rolls designed for bars having sharp corners, will show one bar with

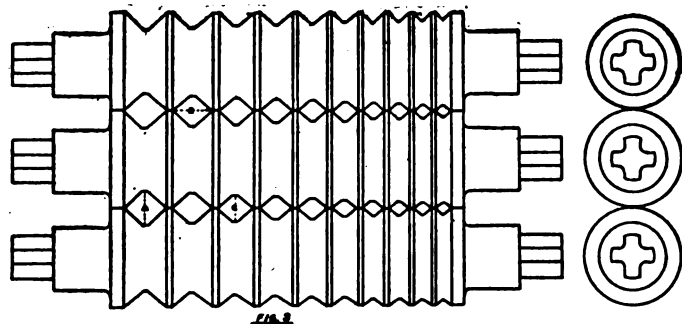


Fig. 3—Open square ruffing rolls.

perfect edges and another where the edges are not quite as sharp as required.

This is especially true on squares, hexagons, octagons, etc., due primarily to the temperature at which the bars are finished. The colder or harder the bar, the sharper the edges, up until full section is produced.

Preventing Fins or Overfills.

One of the most essential features in roll design is to prevent the finning or overfilling of the bar where the two rolling surfaces meet, and still permit the maximum draft to produce the required reduction. An overfill or fin once produced on the bar is never eradicated, but is rolled in and carried through as a seam to the final finished bar, and many bars found spoiled at the finish and attributed to some defect in the finishing rolls, were really spoiled in the roughing rolls.

The writer will endeavor to show in this article, in a nontechnical manner, why a particular design of roll is used to produce a certain bar, when the same bar might have been produced on rolls of entirely different design, and in doing so will trace the successive reductions of a steel ingot into a small round or square rod as the simplest form of rolling.

Blooming the Ingot.

After the ingot has been stripped from the iron mold in which it is cast and this is done while it is still red hot, it is placed in a soaking pit or furnace and reheated until it is of the same heat all through and of a bright yellow color. It is then sent to the blooming rolls, the most common form of which, and the most universally used, is shown at Fig. 1. With this type of roll, a reversing engine or motor is required, as the rolls are only two high. The top roll

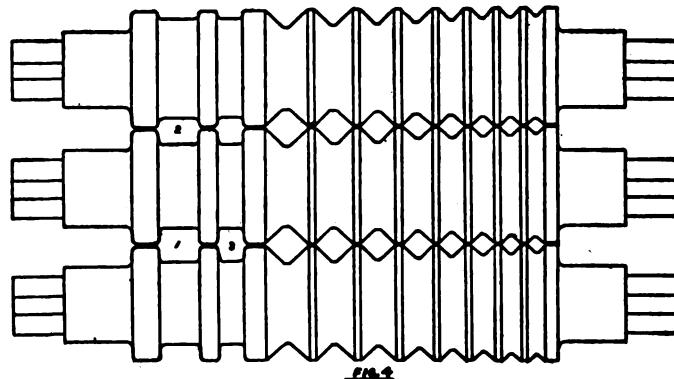


Fig. 4—Combination ruffing rolls.

being adjustable up or down permitting the largest sized ingot to enter between the rolls as shown, and be reduced by successive passes between the rolls, the direction of rotation of the rolls being changed after each pass, until the ingot has been reduced into the size of square or rectangular slab that may be required, within the limit of profitable production. This limit on a square has been set by custom at 4" x 4", as it is not being considered profitable to roll any smaller size on this type of mill and on a rectangular slab at from 1½" to 2" thick.

You will note that the ingot is entered at the center of the rolls on what is known as the slabbing pass, and reduced in thickness until it will enter when placed on its edge, one of the various grooves shown in the roll. These grooves are for the purpose of holding the ingot upright, and preventing it from slanting over and becoming slightly diamond shaped, which would then make it almost impossible to keep the ingot from falling over unless some external means were used to hold it up.

After being given a few passes on edge, bringing it back to a square again, of smaller size, it is again turned down flat on slabbing pass and further reduced until it will enter the next smaller edging groove and

this same process repeated until the size of bloom or slab that is required has been produced.

It is then carried down the roller table to the bloom shear and sheared hot into the various short lengths required for further rolling on the finishing mills.

This type of mill is considered ideal, because any size of bloom or slab, below the size of the ingot can be produced on the same pair of rolls, and as the mill is of the reversing type the roller tables remain fixed, the bloom being driven back and forth through the rolls, by revolving the rollers of the tables, first in one direction and then in the other, the rolls also reversing the direction of their rotation at the same time. The ingot always remaining on the level.

But where a given size of bloom only is required, a three high set of positive pass rolls, such as shown in Fig. 2, is sometimes used, but this requires that the tables be of the lifting type in order to get the ingot into the top groove. However, as the grooves are

each succeeding groove at B is a little wider than the total height of the preceding groove at A, also that a fillet is left in the bottom of the grooves for two reasons. One is to prevent sharp corners, which would get cold and then crack under excessive elongation, and the other reason is to further prevent any overfill at parting of next groove, as the bar is given a quarter turn, before it is entered into the next groove, thus bringing the fillet opposite the opening between the two rolls.

The greater the reduction of the bar, the more open the groove must be. In other words, the wider it must be at the top, in order to prevent a fin, but there is a practical limit to this width, as if the groove is too open or has too large a fillet in the bottom, there is a tendency for the bar to turn down and go through crosswise, thus spoiling the bar and perhaps breaking the roll.

In this type of roughing, the rolls are duplicates, except for a slight difference in diameter; the top roll

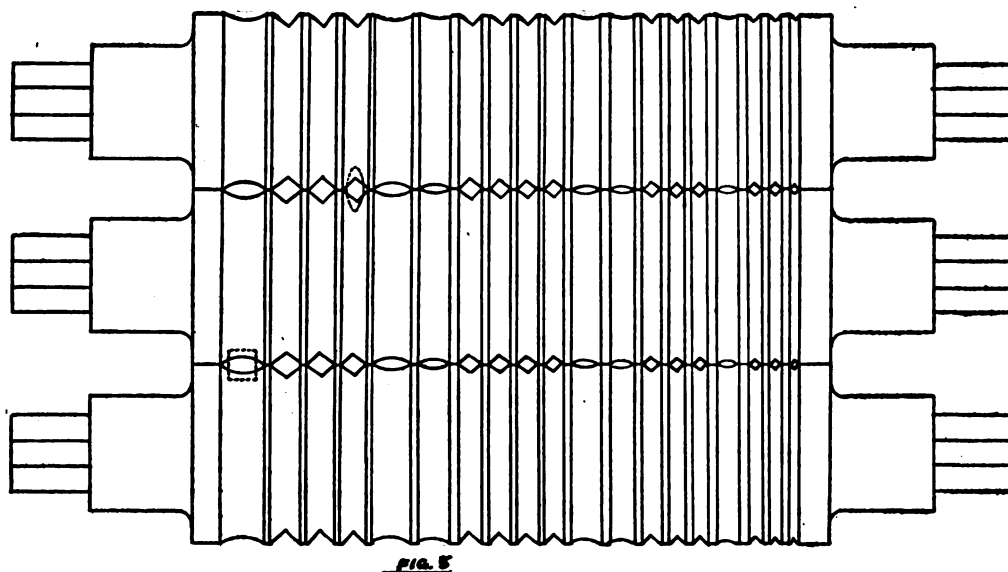


Fig. 5—Strand rolls or pony ruffing rolls.

positive, the resulting bloom will be positive in size and shape, and very little adjustment as to size is possible. But where it can be used it is much cheaper to install, as the driving power is always in one direction, and as it is run at a constant speed, a heavy fly wheel is used to carry the peak loads, and less power need be provided.

Roughing Rolls.

The next step in the production of a merchant bar is the roughing rolls which take the bloom or billet as it comes in short lengths from the bloom shear and after it has been reheated in a furnace, reduces it to still smaller billets for use on other stands of rolls for the production of merchantable bars.

One of the most used and oldest types of roughing rolls for producing standard merchant bars is what is known to the trade as open squares, getting its name from the fact that the grooves are not square but are widened out at one diagonal until the sides are anywhere from three to eight degrees out of square, depending on the purpose for which they are to be used and the material to be rolled on them. Fig. 3 is a sample of open square roughing roll. You will note that

being larger than the middle, and the middle larger than the bottom, to prevent any tendency of the bar to turn up. You will also note that the billet as delivered from the bottom groove is entered into the succeeding groove on top except on the final pass where after being given a quarter turn it is entered into the same groove on top to square the billet up.

The advantage of this type of roughing over other types, is that you can always get a square billet of the size desired, for use in the succeeding stand of rolls, and also that the rolling pressure is exerted from all sides toward the center, tending to produce a more solid billet. This is especially true of rolls turned for rolling iron faggots, built up of muck bar, or muck bar and scrap, as a better weld is produced. It has the disadvantage however, of a great difference in rolling speed, between the opposite diagonals of the billet, due to the difference in diameters of the rolls at bottom and top of the groove, thus compelling considerable slippage of the steel at the various diameters. This in ordinary practice is not taken into account as most steels will stand this abuse without serious detriment, as they are rolled at a fair heat. But there is much conjecture whether many of the small checks,

found in finished bars of high grade tool steel, which must of necessity be rolled at a low heat, are not directly attributable to some such abuse in the roughing rolls.

Combination Roughing Rolls.

The principal advantage of the combination type of roughing rolls, Fig. 4, is that a larger billet can be used than would be safe in the open square type. The first two grooves being made box passes in which the billet is entered flat, and then edged, instead of entering diagonal, thus giving a stronger roll as the diameter at bottom of first two grooves is larger than would be possible if the same billet was entered diagonally. It also requires less length of roll to get the same amount of reduction on the billet than would be

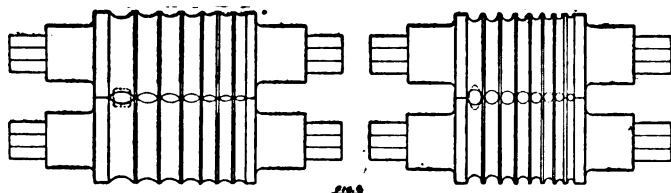


Fig. 6—Leaders and finishing guide rounds.

required if reduction was all by open squares. This type of roughing is in universal use on bar and guide mills and much liked.

Strand or Pony Roughing Rolls.

Strand rolls, Fig. 5, are essentially roughing rolls only, and are used to further reduce the billet to small sizes, and make use of the most rapid method of reduction, that of oval to square, as by this method a greater reduction is possible than could be obtained by open squares alone. This is especially true on small sizes.

You will note that a billet from the first roughing is entered flatwise into the oval, see Fig. 5, and is then turned up edgewise and entered into a much smaller square, with sufficient spread allowed to prevent over filling. This results in a square billet which shows a reduction of from 40 to 50 per cent from the square, that was entered into the oval pass. This process is repeated over and over until the desired billet is obtained from which the finished bar is to be made.

You will also note that the ovals on these rolls are much flatter than those from which a finished round is made, and there are two good reasons for this. First, by this means you get quicker reduction without overfill and second, it prevents its turning down in the square groove, as it would do if it were too thick.

This is the type of reduction used on all wire rod rolls, except that as wire rod rolls are only used for one purpose, namely to produce a wire rod, the rolls would be differently arranged so far as their grooving is concerned, but would use the oval to square process, all the way down to leaders. You will also note that the extra open square passes, shown on these rolls, are for the purpose of getting any intermediate sized billet that may be required.

Leaders and Finishing Rolls.

Leaders and finishing rolls, see Figs. 6 and 7, will depend for their design on the shape of the finished bar, be that round, square, hexagon, octagon, or plain rectangular flat bars, but as the principle is the same

on all, only rounds and squares are shown.

If a round bar made in one pass in finishing rolls, is desired, then the guide method is used, whereby a square billet of the proper size, taken from the strand rolls shown above, is entered flat into a deep oval groove in leaders of the proper size to produce the round required, receiving one pass only in these rolls. It is then enged up between guides for the purpose of holding it upright, and entered into the proper sized round groove in the finishing rolls, receiving one pass only, and the result is a more or less perfect round bar, known to the trade as a guide round, to distinguish it from hand round.

The hand round being produced by a method used on large rounds, in which the bar receives three or

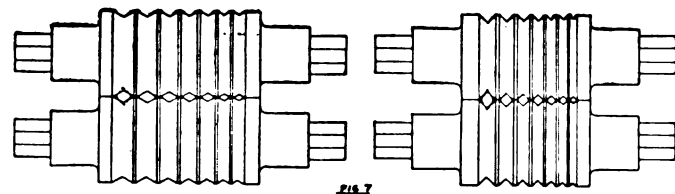


Fig. 7—Leaders and finishing guide squares.

four passes in the finishing groove, and is given a third, to a quarter turn, before each pass.

If a square bar is desired instead of a guide round, then the billet from the strand rolls is entered into the proper sized diamond groove in leaders, then edged up into the square groove in finishing rolls, Fig. 7. The two corners of the square that come opposite the break between finishing rolls, is finished in the diamond pass, and the other two corners in the finishing rolls.

As the bar only receives one pass each, in both the leaders and finishing rolls, these rolls are used two high instead of three high, as shown on the other stands.

MODERN ROLLING OF SPECIAL BEAMS.

(Continued from page 95)

cedure saves time and money besides permitting an easier and better connection to side pieces.

On account of the difference between the metric and English units, it is not possible to make a direct comparison between European wide flanged beams, as rolled in the Differdingen Grey, the Sack and the Puppe mills, with American wide flanged beams, as rolled in the South Bethlehem, Grey and the Slick mills. For this reason, no comparison shall be given, but a few illustrations will be given, showing the application of Puppe beams.

Fig. 2 shows a section through a railroad bridge truss of 16 feet 0 inches width, center to center. The beam section used are given as I P 60, I P 40 and I P 38, corresponding to beams approximately 24, 16 and 15 inches high (the actual dimensions would be 23.62, 15.75 and 14.96 inches).

It is also used in an elevated railroad, built of piece section. The structure in question serves for conveying the iron ore from the mines to the blast furnace at Ilsede, Hanover, which belong to the Peine steel plant.

Concluding, it can be said, that the advent of wide flanged, parallel faced beams has marked a big step toward simplifying the design of structures which are subject to high stresses, representing sections with sound material, and, therefore, without detrimental internal strains.

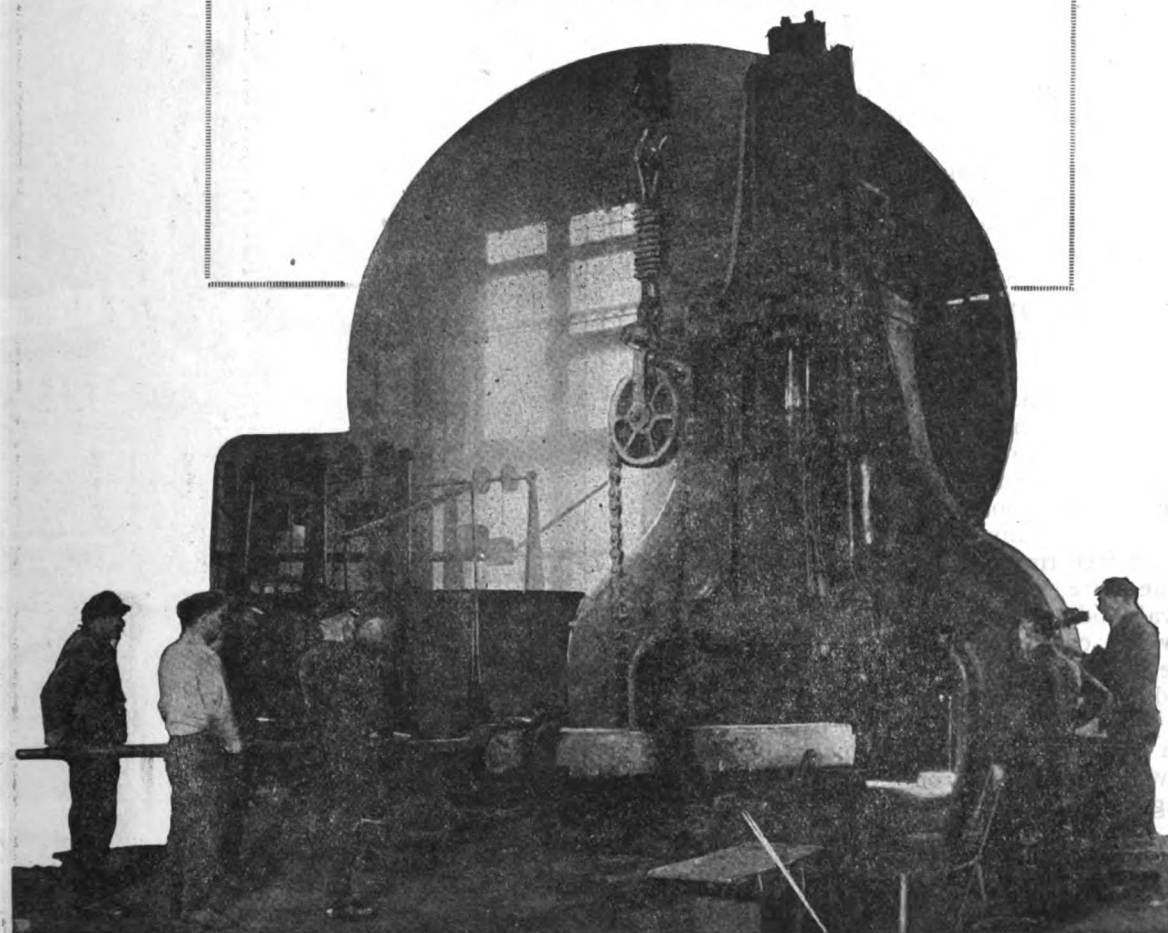
Forging and Heat-Treating Department

Continuous Die Forming
By G. R. NORTON.

Stores Engineering in Industrial Plants
By M. T. MONTGOMERY.

Heating Furnaces and Annealing Furnaces
By W. TRINKS.

Metallography and Heat Treatment of Steel
By WILLIAM J. MERTEN.



Continuous Die Forming

New Process Designed to Roll Variable Section Shapes at the Neville Island Plant of the Witherow Steel Company—Products to Be Manufactured in Alloy and Special Steels.

By G. R. NORTON,

Steel Works Manager, Witherow Steel Company.

FROM the inception of the practice of forming heated metals between rolls into the various bars and shapes, commercially known as rolled products, the improvements on the original process have been along the lines of increasing production by the introduction of mechanical handling devices, increased power and speed and more durable materials for rolls. The character of the product of the mill is essentially the same, being for the most part bars or shapes of constant area and form the section.

By the use of tapering and so-called forging rolls, materials have been formed possessing variable cross sectional areas, such as pipe wrench handles and rifle barrels, to cite two well known examples. Certain mills also roll clip and strap shapes in which rounds, ovals or squares alternate with flats, half ovals or other sections by flattening or otherwise changing the form of the alternating round, oval or square.

Such shapes being rolled between the surfaces of two rolls in one of which an impression has been cut without a corresponding impression in its mate, are never symmetrical about their longitudinal axes, and the round sections are usually somewhat flattened on the side opposite the impression in the forming roll. As such rolls wear in operation, their diameters become smaller shortening the circumferential lengths of the impressions and reducing the longitudinal dimensions of the alternating round and flat on other sectional forms, and at the same time increasing the cross sectional area and changing its shape. A new impression must then be cut on the original diameter of the roll to produce shapes of specified forms and lengths. This process is necessarily limited in the character of its product.

During the war it was found that the stranded cables used as ties between the planes of aircraft offered an appreciable wind resistance and by vibration cut down the speed of the machines. It was desired to replace the cables with some member of the structure which would offer a minimum of wind resistance and be practically free from vibration. For this purpose stream line wire was designed, having an extremely flat oval body with cylindrical terminals at each end by which connections were made to other members of the planes structure. The cross sectional area of the body of the wire was about 25 per cent less than that of the terminals, and all parts of the wire were on a common axis and symmetrical about it. Each wire was to be made from one piece of steel without welding or upsetting.

Stream line wire was produced by cold rolling from a round bar to the flat oval body and by swaging, but as neither process was entirely satisfactory as to quality and quantity the problem of forming this bar with its varying sections was attacked by the Witherow Steel Company and after a very considerable amount of research and experimental work was

solved, so that stream line wire in various sizes and lengths was produced in quantity by rolling on one heat.

In order to make the production of variable section bars possible on a commercial basis, the solution

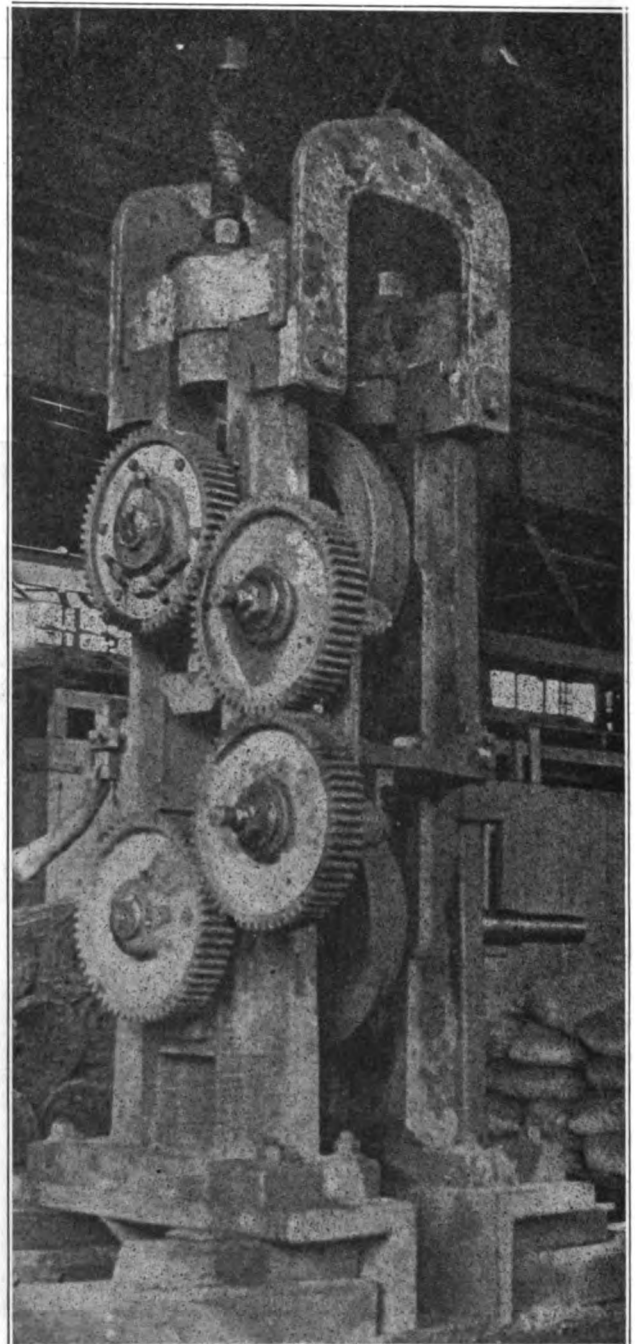


Fig. 1—Special mill for rolling long lengths.

of three distinct problems was necessary and these were: (a) That to roll several sections symmetrical about a common axis in one bar, an impression must be formed in the surfaces of both rolls between which the bar is formed and that the two impressions must match exactly during the entire pass. (b) That in order to produce work within the very close limits specified, some type of roll which would permit frequent dressing must be used, and that the loss by wear and dressing in the diameter of the roll must be compensated. (c) That some method must be provided of entering the pass so that the end of the leader would meet the end of the impression and avoid the production of partial lengths involving a high proportion of scrap.

The exact matching of the impressions in the opposing rolls was effected by supporting them in extremely rigid and heavy housings of sufficient height

This design adequately serves to meet the requirements of ease in dressing impressions and compensation for losses in diameter, as the built up segmental ring may be expanded to its original diameter with a small expenditure of time, labor and material, while an almost indefinite number of dressings is possible.

To properly enter the pass so the entering end of the leader will be engaged in the end of the impression in the rolls, an electrically operated gate or stop is synchronized with the end of the impression, so as this point on the rolls arrives in its rotation in the proper position the gate is released and the leader entered.

After the armistice the manufacture of stream line wire was discontinued but the segmental rolls were employed in the production of a strictly tonnage commodity—deformed reinforcing bars—and their per-

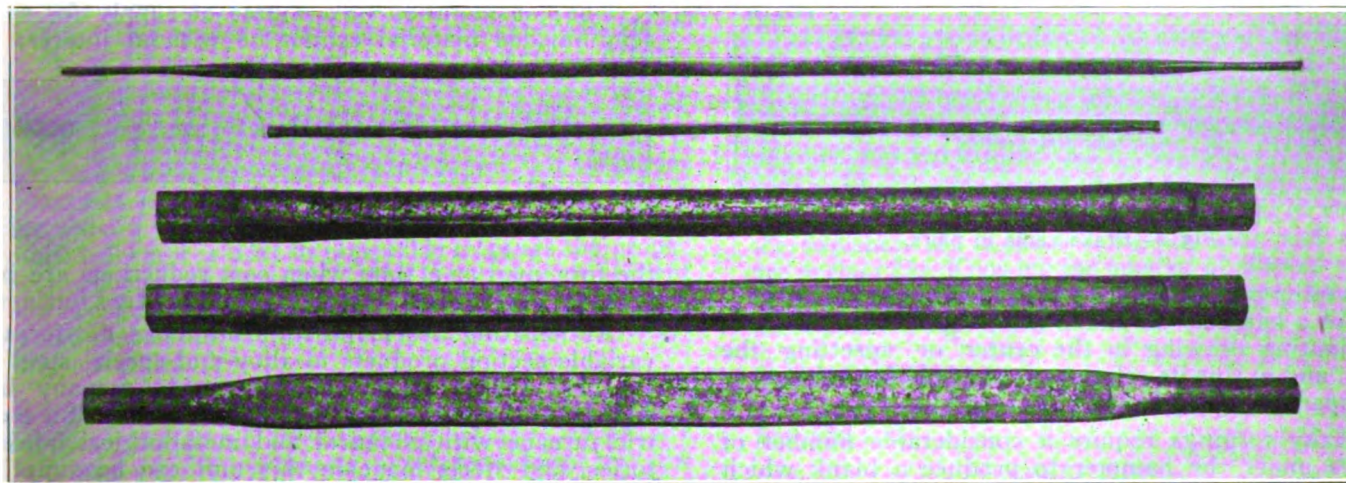


Fig. 2—Types of continuous die-formed products produced by Witherow Steel Company.

to permit the use of rolls from 18" to 68" in diameter which were made to rotate in any desired relation to each other by a train of adjustable gears mounted on one of the housings. Top and bottom screws give vertical movement to the rolls and micrometer adjustment is provided by a vernier dial which indicates the spacing of the rolls. As only one pass is made through the forming rolls, their faces are narrow and the distance between housings small so the spring of the rolls under pressure is negligible and the size of the pass may be regulated with a high degree of accuracy.

After making provision for the exact matching of the impressions, the design of rolls was considered which would satisfy the given conditions of facility in dressing and means of compensating for the inevitable loss in diameter through wear and dressing.

It is obvious that a solid roll cannot be made to meet such requirements, so a built up construction was adopted in which the active faces of the rolls were made of hardened steel segments in which the impressions were cut, the ring formed by the assembled segments being carried on the body of a mandrel which was grooved in its periphery to provide a seat for the inside of the segmental ring, and equipped with devices for locking the segments in position. The ends of the mandrels are formed into necks which serve as journals and to carry the matching and driving gears.

formance on many thousand tons of this material fully justified the confidence of their designers.

The roll matching gear train, segmental roll construction and automatic entering gate were the inventions of George Baehr, general superintendent of the Neville Island Mill, while the development of the process and its present commercial establishment is due to the efforts of W. P. Witherow, president of the company. The features of design and their application to rolling mills have been fully covered by basic patents in the United States and other countries.

The Witherow Steel Company operates its plant on Neville Island, (Pittsburgh district), its equipment consisting of 12 stands, 14" rolls and 5 stands 9" rolls, and in addition to these roll trains the specially designed stand originally built for the rolling of stream line wire. The finishing stands of the 9" and 14" mills are equipped with matching gears and mandrels so that suitable leaders are rolled from billets on the roughing and strand rolls and formed into variable section shapes in the final pass on the finishing stands without reheating. Leaders for the special mill are rolled on either the 9" or 14" mills, and finished in the same heat.

In cases where variable section material is required in lengths less than the circumference of the smallest roll possible to operate in the 9" mill, multiple impressions are cut in the rolls and two or more pieces,

gated together and to those following are produced at each revolution of the rolls. Lengths up to about 17 feet can be rolled on the special mill when equipped with the maximum size rolls.

Reductions in sectional area, both with and without a change in sectional form, have been accomplished, and as each variation in section presents its individual problem, it is impossible to predict exactly the limitations of the process.

The accompanying illustrations will convey an idea of the character of work produced and the possibilities of "continuous die forming" as this method of manufacturing has been termed. It will also be apparent that it is essentially a process requiring quantity production for economy of operation.

The action of rolls upon heated metal is analogous in results to drawing under the hammer except that the former is continuous and faster. In variable sec-

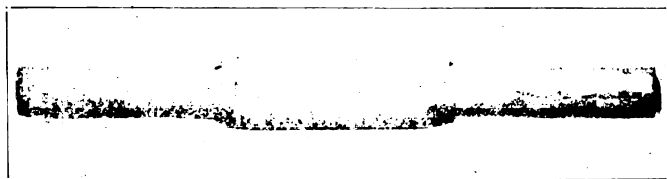


Fig. 3—Brake cams in pairs.

tion rolling reductions in area between the extremities of a bar may be made in one operation and heat, eliminating drawing in the center or upsetting the ends, and in this its relation to the drop forge industry is apparent.

Many forgings require a considerable number of blows under the hammer to produce a blank which can be struck in the finishing impression to produce the ultimate form of the forging. Such blanks by reason of the character of the work frequently contain a large amount of metal in excess of the weight of the finished piece, this excess appearing as flash and tongholds, so that it is not unusual for one pound of finished forging to require from two to three pounds

of stock for its manufacture. This is no inconsiderable item in cost when freight and handling charges are considered in addition to the cost of the stock itself, particularly in the use of high priced alloy and special steels.

By continuous die forming, convenient lengths of multiple blanks can be rolled, closely approximating the finished forging weights and these blanks may be struck directly in the finishing impression in the die with but little wastage of stock or struck after edging if the piece requires bending.

The cutting of roughing impressions in the dies is thus saved and the time of the roughing blows, which are likely to be more than 50 per cent of the total number struck, as well as making possible the use of smaller die blocks by the elimination of impressions. It cannot be claimed that blanks for all forgings can be manufactured by this process, as many shapes required for the purpose would be impossible to roll.

The consideration of a source of supply for such semi-finished material cannot be without interest to

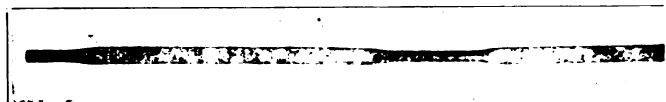


Fig. 4—Tie rods as rolled.

the forgerman at a time when cost reductions are imperative for survival in a highly competitive business.

Anticipating a demand for continuous die formed variable section products in alloy and special steel of the best quality, the Witherow Steel Company has added to its equipment at Neville Island a 10-ton electric furnace with chemical and metallurgical laboratories, and steels made in this unit can be supplied either in bars of variable section or the usual shapes as supplemental to open hearth carbon and alloy steels. Provision has been made in the plant layout for additions to the melting and rolling equipment, the additions to the latter to be in units of the special mill type for continuous die forming of variable section shapes only.

Stores Engineering in Industrial Plants

The Relationship of the Stores Department to the Operating Department—Reciprocal Relation to the Purchasing—How a Stores Department Can Be Established Along Engineering Details.

By M. T. MONTGOMERY,
Pittsburgh Railway Company.

OF ALL phases of operation which form the entity of a plant, the question of properly caring for materials has not generally received the consideration it deserves. It was not considered of sufficient importance because the development of facilities entering into the manufacturing of products demanded most of the attention of those who kept pace with the times.

Since the intrinsic value of materials has greatly increased, the investments in unapplied materials assume

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large proportions. The question of storekeeping has been looked upon more or less as a function subservient to purchasing. While it is true that they are co-ordinate, the actual handling of materials should be accorded a field of its own.

The word "Storing" means the place of materials for safekeeping. This implies that the goods have a value. A great deal of money is being spent for attractiveness of premises where valuables are stored; correspondingly, much trouble is taken with the inner arrangement of such places, as well as the handling of the valuables.

A certain part of a machine is not as attractive as a

piece of jewelry, or an elaborate gown, yet it costs at least as much, if not more. It is, of course, obvious that it is not necessary to display its attractive surroundings but it ought to be taken care of just as carefully as any article representing outlay of money.

I wish to state right at the outset that while the methods of stores engineering practices by us may not be applicable in every detail to other lines of endeavor, it is my hope however that the conclusions you draw will be helpful to you if you are confronted with the question of properly caring for materials.

The street railway business depends a great deal upon an efficient stores department. Since the replenishing of materials emanates from this source, we are called upon to keep up our stock of materials, in our case consisting of 8634 different items.

Economic Aspects.

The function of the stores department is to give service, and this means always having enough materials in stock to fill the requirements of the operating departments. In this, 100 per cent efficiency cannot be attained. Causes beyond human control, such as inclement weather, labor problems, and transportation difficulties, make it impossible to lay down absolute maximum and minimum quantities of materials to be carried in stock. With methods in vogue with most plants using stock cards or stock ledgers it is next to impossible to gauge the proper requisitioning of materials. The importance of efficient stores engineering depends upon the adoption of a system which enables one to provide for not more than the necessary quantities.

Reciprocal Relation to Purchasing.

According to our way of doing business, we prepare and send to the purchasing agent requisitions for the replenishing of materials and supplies. We consider a requisition a potential purchase and since this means actual outlay of money too much care cannot be taken to order the proper amounts and order them in sufficient time for actual needs, taking into consideration delays incidental to manufacturing and transportation.

As I see it, the purchasing agent's function is to place orders for goods to the best advantage both as to price and delivery. It is of the utmost importance that close cooperation be observed between the two departments. We are fortunate in having a purchasing agent who fully realizes the importance of our department. We get together with him at least once a week and discuss the difficulties we may encounter in procuring materials, as he is in close touch with market conditions.

Our requisitions are prepared in such a way as to list only kindred materials on one separate requisition and if our records based on actual experience indicate that we use a great deal of certain materials during the year we give the purchasing agent the opportunity to get better prices and deliveries by ordering larger amounts on protracted deliveries.

Unless a certain repair part is peculiar to certain type equipment in which case we of course show the makers name—we do not show on the requisitions any preference for any vendor.

If any materials are bought to certain specifications we have them tested.

In these times when hardly any manufacturer's promise is being fully lived up to, the problem of hurrying materials is very important and seeing that we are in closest touch with the demand we do this ourselves.

Classification of Materials.

All materials and supplies handled by us are classified and are known by a class number which takes the place of, and is identical with lot numbers or catalog numbers.

In classifying our stock we consider the physical properties of the materials and the equipment to which they belong.

Our materials are divided into five main groups.

- Way structures.
- Power transmission.
- Equipment of cars.
- Transportation.
- General.

Each of these groups is again divided into classes according to the kind of materials used. Taking the equipment of cars, some of the classes are: Iron, lumber, castings, bolts, motor parts, bearings, lamps, wheels, and axles.

While our classification of 76 classes may not be applicable to any other line of business it is illustrative.

A manager of a plant, being interested in his assets represented in unapplied materials, would naturally want to know what constitutes this investment.

The class number itself shows two things. The first two digits show the class proper and the rest of the digits the sequence, for instance: all bolts, nuts, and washers are in class 25. Knowing the number of sizes of machine bolts we assign certain blocks of numbers, bearing in mind possible expression in sizes or kinds.

Stores Department.

Aim—The chief aim of the department is service—first and last.

FUNCTION.

- Caring for and handling new materials.
- Replenishing stock.
- Delivering all supplies when and where needed.
- Gathering up of scrap.
- Sorting and shipping scrap.
- Disposing of obsolete material.
- Stock records.

Stores Calendar.

No work can be accomplished properly unless it follows a concise plan. This holds especially true in our line when so many of the things to be done depend in some measure on seasonal requirements.

Therefore we have a stores department calendar dividing the things to be done by months, weeks, and days. The activities noted thereon do not by any means comprise all of our functions but remind us of certain things which must be done year in and year out. Much of the street railway business can be done only at certain times of the year, and this calendar was drawn up to meet these conditions.

Organization.

Then as to our organization chart. No matter how clearly one may define a plan of activities it cannot be successfully carried out unless everyone in the organization does his share.

While each one is assigned a certain sphere of activity it is expected he will reach out for the job ahead. We educate our employees to the best of our ability and train them for better jobs within our organization.

Owing to the nature of the business it is necessary to conduct several branch stores in addition to the general

store. These are located near the larger repair shops, and are in charge of division storekeepers.

The stores inspector is responsible for the efficient handling of the division stores and the assistant general storekeeper is responsible for the conduct of the general stores. The office work is in charge of a chief clerk and the manual operations are in charge of a foreman.

Relation to Efficient Operation.

Our stores calendar and organization chart, are drawn up with a view to giving the most efficient service to the operating departments. Nowadays, when labor is at a premium and the question of average hourly rate of pay has greatly increased, it is imperative that the men should not loaf on the jobs for want of materials or be compelled to spend unnecessary time in making substitutes.

As a great deal of work is being done which cannot be properly classified as ordinary maintenance such as changing over of equipment, etc., it behooves the operating department to advise us of its expected needs, but we go further than that and through daily visits made to the various foremen we keep in touch with their particular needs.

Manual Operation.

Location—No matter how carefully a plan may be drawn up or how efficient an organization may be on paper, stores engineering becomes a failure unless the stock is properly arranged. In our business the main shops are located in Homewood, about a mile distant from the Pennsylvania Railroad Company's siding at East Liberty. This necessitates the handling of bulky materials such as rails, special work, wheels, poles, brake-shoes, ballast, and coal, coke paving materials, etc., at that point to avoid unnecessary handling.

Storing.

Though it may sound illogical the first requisite of storing is not elaborate surroundings or intricate paraphernalia, but cleanliness. I have seen stores in industrial lines as well as my own line, and many of them seem to be in need of a good bath and scrubbing. It pays to instill the sense of cleanliness into the minds of those who handle the material.

The laying out of a store is a matter that is generally given consideration long after the plant is finished. I have seen car houses and shops where everything was 100 per cent plus as far as modern equipment, sanitation, proper labor saving devices, and all other improvements were concerned but the stores department had to content itself with inadequate quarters and makeshift arrangements. For some inexplicable reason it was thought that any old arrangement was good enough to house materials. It may be said in all justice that engineers are now giving due consideration to the proper storing of materials, as evinced by your invitation to present the experiences of a storekeeper engaged in street railway business.

Each plant has its own problems, depending on the kind of goods manufactured, therefore, no set rules can be laid down regarding the proper laying out of a store; however the principles which I am about to enumerate are applicable to any store.

- Maximum visibility.
- Orderly piling.
- Absence of drawers.
- Proper packaging.
- Everything on wheels.

Our general stores are divided into sections, each kind of material grouped together forming a section. Each section is in charge of a stock man and helpers. The stock man is responsible for the physical upkeep of the section, including the storing, counting, and issuing of materials. Owing to the nature of the materials we handle we cannot adhere to standard sizes of cases but all cases are of the same height and width. Since it is not possible, on account of the quantity of materials handled, to put the entire stock into bins we have an annex or warehouse where the overflow material is kept. Each stock man takes care of that portion of the warehouse that houses material he handles.

We have a systematic layout of our cases. The aisle room is the same all through the stores. Waste-baskets are placed at proper intervals and they are used.

The cases are numbered. The first letter shows the section and the second letter shows the sequence of the bins. In addition, each bin is numbered and the case as well as the bin number is marked on our stock records for location reference.

A great many stores have a face board in front of the bin to allow them to use a larger size bin tag which identifies the material. We found these to be great dust collectors, therefore we did away with them and have designed a bin tag receptacle which fastens on the shelves and is so constructed that the tag may be easily removed.

Bin tags written on the typewriter are placed in this receptacle. The sheet used for this purpose is perforated so that it is flexible. On this tag we give full description of the material, class number, and also cross reference to the stock record.

Materials like pencils or small tools which are apt to travel fast if not properly looked after are kept locked up with the keys in possession of the stock clerk.

Our oil house is a source of great pride to us. That portion of any store, as a rule, is the least presentable.

By insistence on scrubbing the floors once a week with a mixture of caustic soda and sawdust we manage to keep the floors absolutely clean.

Our iron and steel stock is kept in the same orderly way as the rest of our material. A scale, placed in the middle of the layout runs on tracks and so facilitates handling.

Owing to lack of space we are compelled to house in the open a great many materials of bulk nature which do not deteriorate in inclement weather.

Orderly Piling.

The first requisite of stores engineering is cleanliness, and nothing can be kept clean unless piled in an orderly fashion. Take for instance, the manner in which we pile our bolts. Most people who saw our arrangement viewed this particular phase with a certain amount of misgiving. It seemed to them more or less of a hobby, and an expensive one at that, rather than an absolute necessity. It should not be necessary for me to convince you that it is a great deal more economical to pile goods in an orderly way than to throw material helter-skelter into receptacles.

Maximum Visibility.

Since we count our stock once a month it is necessary to do the work as quickly as possible and as accurately as possible. Our stores department calendar provides six days for actual taking of stock. The stock men do this attending to their regular duties in addition. If materials were piled in a disorderly fashion this could not be accom-

plished neither would we get anywhere if the bulk of the stock had to be counted by handling each piece. To count most of our material without actually handling it we designed screen backs for our cases.

Drawers.

As we insist upon counting the materials without handling we did away with the use of drawers. They were used for the storing of very small parts of electrical apparatus. We converted this ancient machinery into modern bins.

Proper Packaging.

Contrary to the belief of most operating men it does not cost any more to have vendors ship material in specified containers instead of according to the commercial practice.

As far as possible, we make no change from established practice but in some instances we insist on packaging according to our own needs based on the quantities in which the materials are disbursed; for instance, most manufacturers ship line cars, which support the overhead trolley wire, in barrels of from 180 to 220. We insist that they be shipped in boxes of 50.

Armature coils for the rewinding of railway motors we specify in boxes of one set. Small screws which are not of the standard commercial variety we order shipped in packages of 100 and so on down the line.

Everything On Wheels.

Economic operation depends on getting the most work done for the least number of man hours expended. Our success in this line may be attributed to the common sense application of automatic lifting trucks, and platforms, which means potentially, "Everything on Wheels".

While these appliances are primarily labor saving devices, they tend to prevent accidents.

Inventories.

As mentioned before, we count our stock once a month and our annual inventory does not differ at all from our regular stock taking except that it is taken under the supervision of the auditor. In the efficiency of our inventories we price ourselves on a standard comparable with the purity of "Ivory Soap". Our last annual inventory comparison which was compiled by the auditor independently of our records showed a discrepancy of \$1,682 which is equivalent to 0.11 of 1 per cent of the value of materials handled for the year.

Heating Furnaces and Annealing Furnaces

Continuous Furnaces for Round Shapes and For Sheets and Plates—Continuous Furnaces With Helical Conveyor—Rotating Hearth Furnace as Continuous Conveyor of Material-to-be-Heated.

By W. TRINKS.

PART XXV.

CONTINUING in the discussion of continuous furnaces we find that the seventh method, namely, that of rolling round material down an inclined hearth, is rather limited in its application, because it applies only to cylindrical objects. Conical bodies will not roll straight ahead, neither will any round object which touches the hearth with two different diameters. In consequence, this method is limited to the heating of round bars for wheel mills, axle forges and seamless tube mills. In war times, there is added the heating of shell blanks for piercing or annealing purposes*. Fig. 190 shows a heating furnace for shells.

The round shape which assists in moving the cylindrical pieces through the furnace calls for a precautionary measure against accidental discharge of all of the cylinders in the furnace. If rails are used in the furnace, the slant commonly used equals 1 in 30, while without rails it can be somewhat greater. If that inclination were used all of the way to the end, the cylinders would roll out of the furnace. The trouble is avoided by adding a horizontal section, or by providing a lock system which discharges only one cylinder at a time. The horizontal section is indicated in Fig. 190. Where rails are provided, they can be notched. The notches help to stop the cylinders and besides, act as separators. In the heating of cylinders up to 2,200 degrees F., no rails or hearth bars are used, and the cylinders roll on sand, magnesite or chrome ore.

Automatic discharge is not practiced with this type of feeding, and would indeed be difficult of accomplishment, unless a positive lock is used. For as soon as one cylinder is withdrawn, the rest of them loosen up from the bottom and roll forward, until friction at the horizontal run stops them, again, from the bottom up. This means that cylinders must be withdrawn singly from the horizontal run, which is commonly done by hand.

Continuous heating furnaces (2,200 degrees F.) for rolling rounds are equipped with trouble doors from one end to the other, because the cylinders will occasionally stick together, particularly if they are held in the furnace for a considerable length of time on account of trouble in the mill.

The eighth method, namely, that of passing flat material over rollers in the furnace hearth, is used to a considerable extent in the annealing of sheets and of thin plates. The method was originated by T. Costello, and furnaces conveying material in that manner are commonly known as Costello furnaces. Fig. 191 shows the type of roller which was originally used, while Fig. 192 illustrates a furnace with a more modern type of roller. (The G. J. Hagan Company, Pittsburgh.) The former was built up of refractory rings which were held together by a spring, so as to allow unhindered expansion. The curvature, which

*Taken from Lynch, "Heat Treatment of Steel," Engineers' Society of Western Pennsylvania, June, 1919.

was intended to keep the plates in the center of the roller, caused a zig-zag motion and was later abandoned. The refractory rollers did not do well at the firing end and were replaced by steel discs on a water cooled shaft. Any given point on the periphery of a steel disc is below the hearth during a large part of the time and is exposed to furnace heat only a comparatively short time. The discs work very well except at the hot end of furnaces fired with powdered coal. The ash fills the spaces between discs and hearths, causing the discs to bind, wear away and to finally break the driving mechanism. The trouble has been overcome by rotating water cooled pipes (squirrel cage fashion) at the firing end, see Fig. 193, and by arranging the discs above the hearth away from the

This type of furnace produces "open annealing", and in consequence, requires a neutral or reducing flame, if excessive scaling of thin sheets is to be avoided. Continuous muffle type furnaces with rollers have been patented, but apparently have not been reduced to practice.

The ninth method, namely, that of pulling endless material, such as wire or chains, through annealing or tempering furnaces is, of course, very limited in its application. Wire is either pulled through a lead bath (lead annealing) or through hollow tile which acts as a muffle. In either case, the wire passes over rollers which maintain a moderate tension on the wire. This can be accomplished by a friction drive on the pulling side, and friction drag on the entering side.

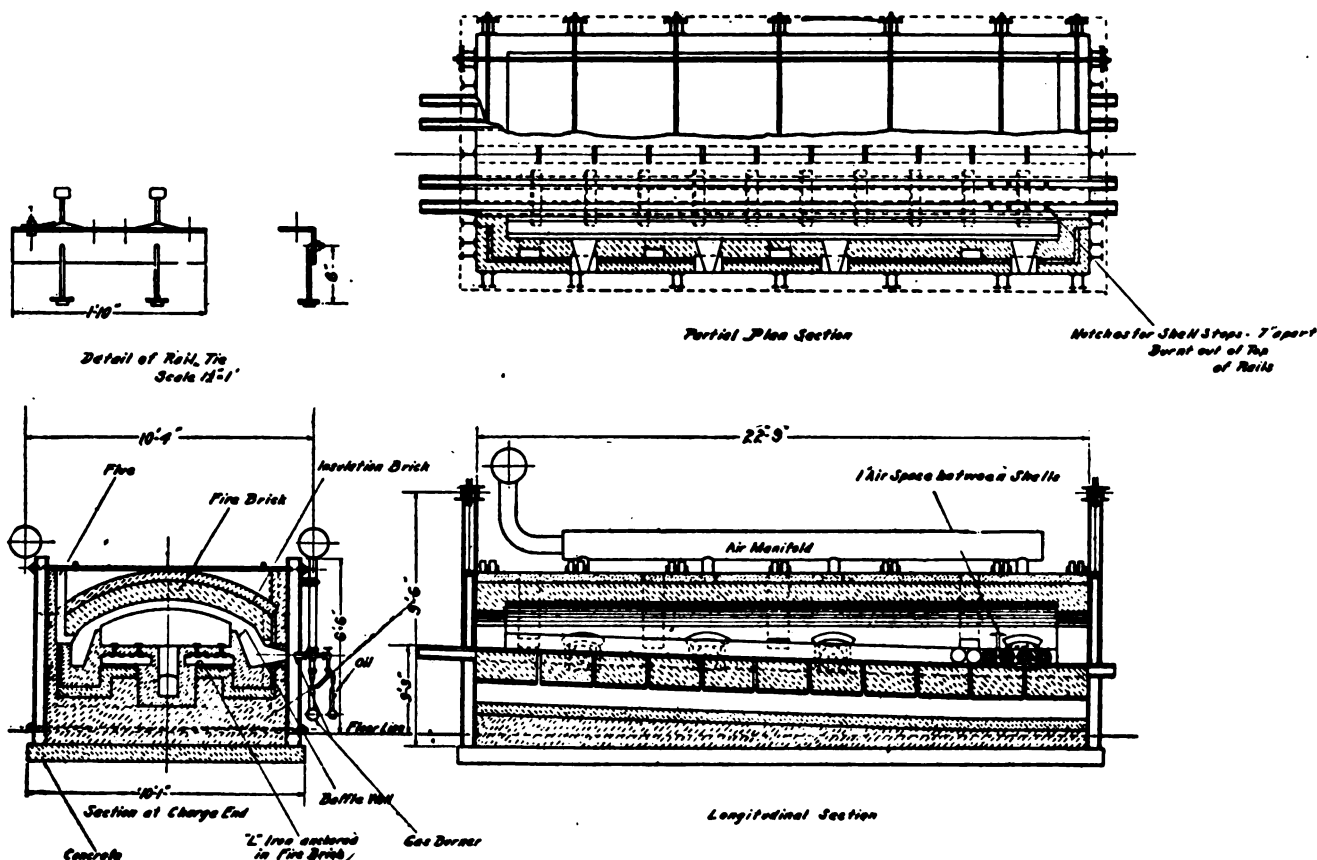


Fig. 190.

firing end, (method used by Tate-Jones & Co., Pittsburgh, Pa.)

It should be noted that, in these furnaces, the sheets enter at the hot end. The purpose of this arrangement is to avoid overheating the sheets, without having to resort to perforated bridge-walls or arches. Furthermore, the arrangement protects the rollers. The latter can be covered by sheets or plates almost all of the time at the entering end, but are exposed at the discharge end, to the interior of the furnace for a considerable length of time. This difference is due to the fact that the sheets or plates must be removed quickly from the furnace. Sheets must be removed quickly, because of oxidation, and heavy plates must be removed quickly on account of cooling. No matter whether the stock is moved out quickly either by having the rolls at the discharge end move at higher speed or else by being pulled out, the rollers are exposed to the furnace interior more than 50 per cent of the time.

The tenth method, namely, that of "screwing" the material through the furnace, was brought to a high stage of perfection by the Rockwell Company. Fig. 194 shows a Rockwell rotary annealing and hardening furnace, and brings out the details. (See also Fig. 96, part 13.) The refractory lining has helical ribs. Friction carries the material which is being heated up along the walls, and gravity causes it to fall down again to the bottom. If a piece could ride astride one of the ribs, it would be carried around without progressing axially. This brief statement assigns a definite field to the furnace. It cannot conveniently be used for temperatures above 1,700 to 1,800 degrees F., because the helical ribs lose their strength. Ball-shaped material is most easily heated in the screw conveyor furnace, because it rolls back to the bottom most easily, while irregular shapes are carried higher up along the sides and injure the ribs in falling back. Nevertheless, the field, although definite, is quite large, and the furnace is adapted to handle, either for

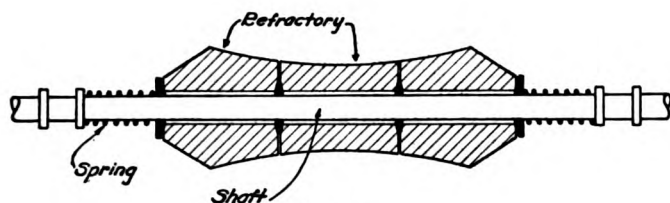


Fig. 191.

annealing, hardening, tempering, or blueing, any small pieces of like dimensions in either brass, copper, steel or other metals, such as eyelets, ferrules, buttons, caps, cups, coin blanks, steel balls, saw teeth, tacks, screws, rivets, rings, certain types of springs, nuts, punchings, in fact any small pieces which will travel freely and pass through the openings without chaking them.

Referred to the furnace proper, disregarding its overhanging hoods, the capacity in pounds per hour per square foot of projected internal furnace area equals from 65 to 90 pounds.

The illustration very clearly brings out the circumstance that the material can be shoveled in quantity into the charging drum and is automatically delivered at the other end either to a quenching tank or a blueing tank, or to a conveying device.

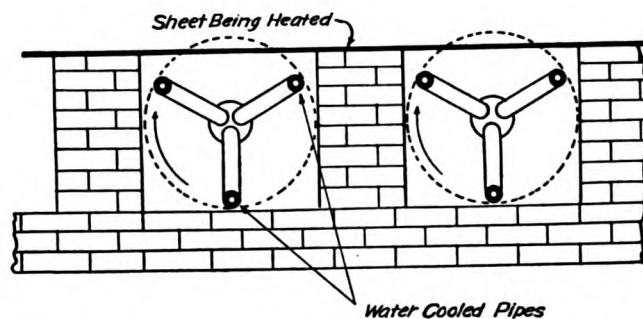


Fig. 193.

It has been attempted to adapt the furnace to material which "sticks between the ribs" by changing it to an inclined furnace without ribs, and by adapting the inclination to the material which is being handled. This method is not absolutely certain as to the time during which the material is in the furnace and, for that reason, is not as reliable in its results as the screw conveyor type.

The straight line continuous furnace has, without any doubt, the great advantage of moving the material through the shop in a logical manner, maintaining a constant direction of travel, but it also has the disad-

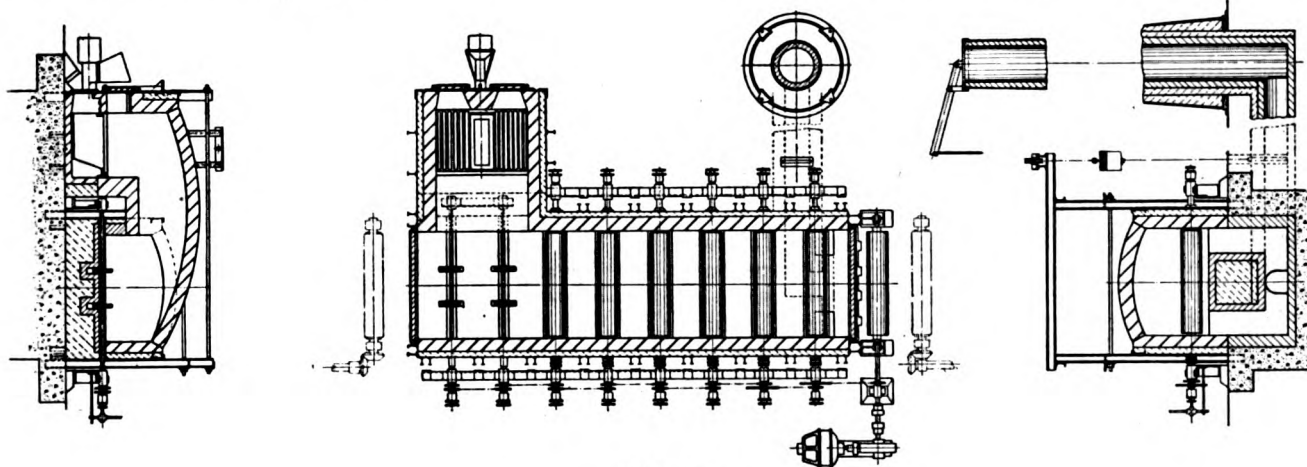


Fig. 192.

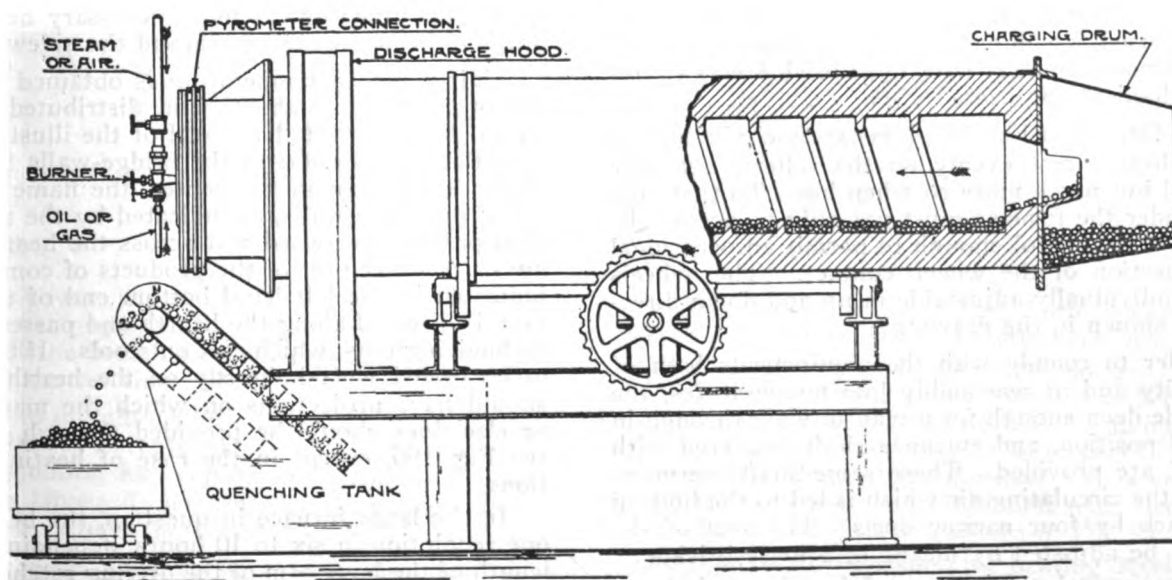


Fig. 194.

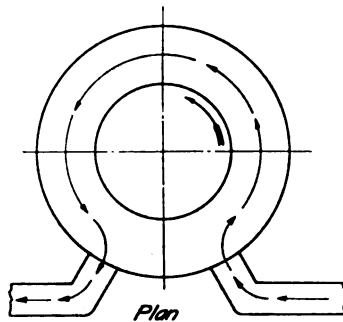


Fig. 195.

vantage that irregular shapes cannot be moved through it except on cars, or in trays, which, of course, means heat losses and the inconvenience of bringing the cars or trays back again to the charging end. The rotating hearth, a plan view of which, together with approach and delivery tables, is shown diagrammatically in Fig. 195, avoids much of this trouble. The material can still be made to travel through the shop in a straight line, except that there is a big loop in that line, wherever the furnace is located. This arrangement causes no trouble except where several sets of materials are moving through the shop in parallel lines. In that case, the round furnace is liable to result in waste space, unless the furnaces can be staggered.

In all other respects, the round furnace is advantageous. The material which is to be heated is placed on the hot hearth and is carried around on it. There is no pusher, there are no hearth bars, no cold spots in the hearth; there is no buckling of the material or piling of the pieces on top of each other.

Fig. 196, (General Combustion Company), shows a rotating hearth furnace of medium dimensions, while Fig. 197, (Tate-Jones Company) illustrates a fairly large rotating hearth furnace. When the furnaces shown in this latter illustration were under construction, almost everyone predicted dire failure, because large rotating hearths "had always given trouble", and because it would "be impossible to get uniform temperature distribution". In spite of these black prophecies, the furnaces are in excellent operation. In the design and in the erection of large rotating-hearth furnaces, some precautions must, of course, be used, which had heretofore been overlooked, because furnace builders have been brick layers rather than mechanical engineers.

In the furnace of Fig. 197, it is extremely important that the hearth rest evenly on the rollers, not only when cold but much more so when hot. To that end, the pit under the furnace must not only be accessible, but must be kept cool enough to permit an occasional brief inspection of the wheel contact. The wheels must be individually adjustable in up and down direction (not shown in the drawing).

In order to comply with the requirements both of accessibility and of reasonably low temperatures, the pit is made deep enough for a man to walk through in a stooped position, and entrance shafts, covered with a grating, are provided. These same shafts serve as inlets for the circulating air which is led to the bottom of the stack by four narrow ducts. The area of the latter can be adjusted by means of a loose brick.

The horizontal thrust caused by the main gear drive is taken up by separate rollers (not shown)

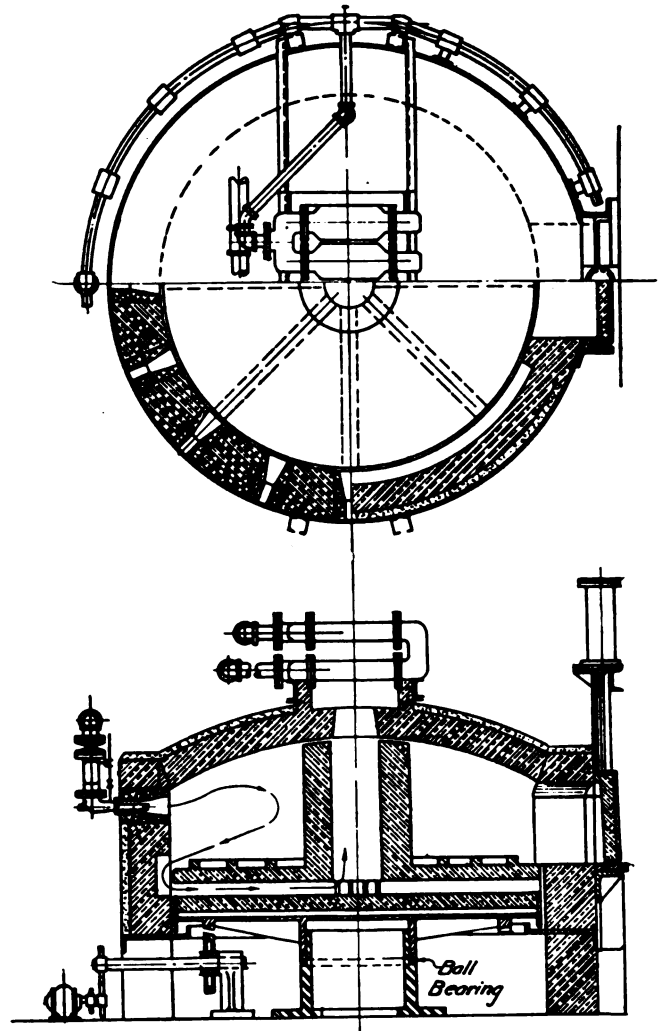


Fig. 196.

bearing against the track. The seal between the heating chamber and the pit is effected by silocel powder instead of sand, because it was found to offer less resistance to motion. The seal chambers have flap doors through which the sealing material can be removed at regular intervals. This is necessary because scale drops in between the hearth and the sidewalls.

Uniformity of temperature is obtained by guiding the products of combustion in distributed directions. From the upper left hand end of the illustration, it is seen that, on account of the bridge-walls being lower at the sides than in the center, the flame is directed along the outer walls, as indicated by the arrows, and then passes downward and across the hearth into the flues. Another part of the products of combustion, as indicated in the left hand bottom end of the illustration, is directed along the hearth and passes under the carbonizing pots, which rest on stools. If the material to be heated is laid directly on the hearth, the latter should have projections on which the material rests, or else flues should be provided through the hearth, see Fig. 196, except in the case of heating thin sections.

In the large furnace in question, the hearth makes one revolution in six to 10 hours, depending upon the length of the lever arm of the driving ratchet. In con-

*Patents are pending on the principal features of this furnace.

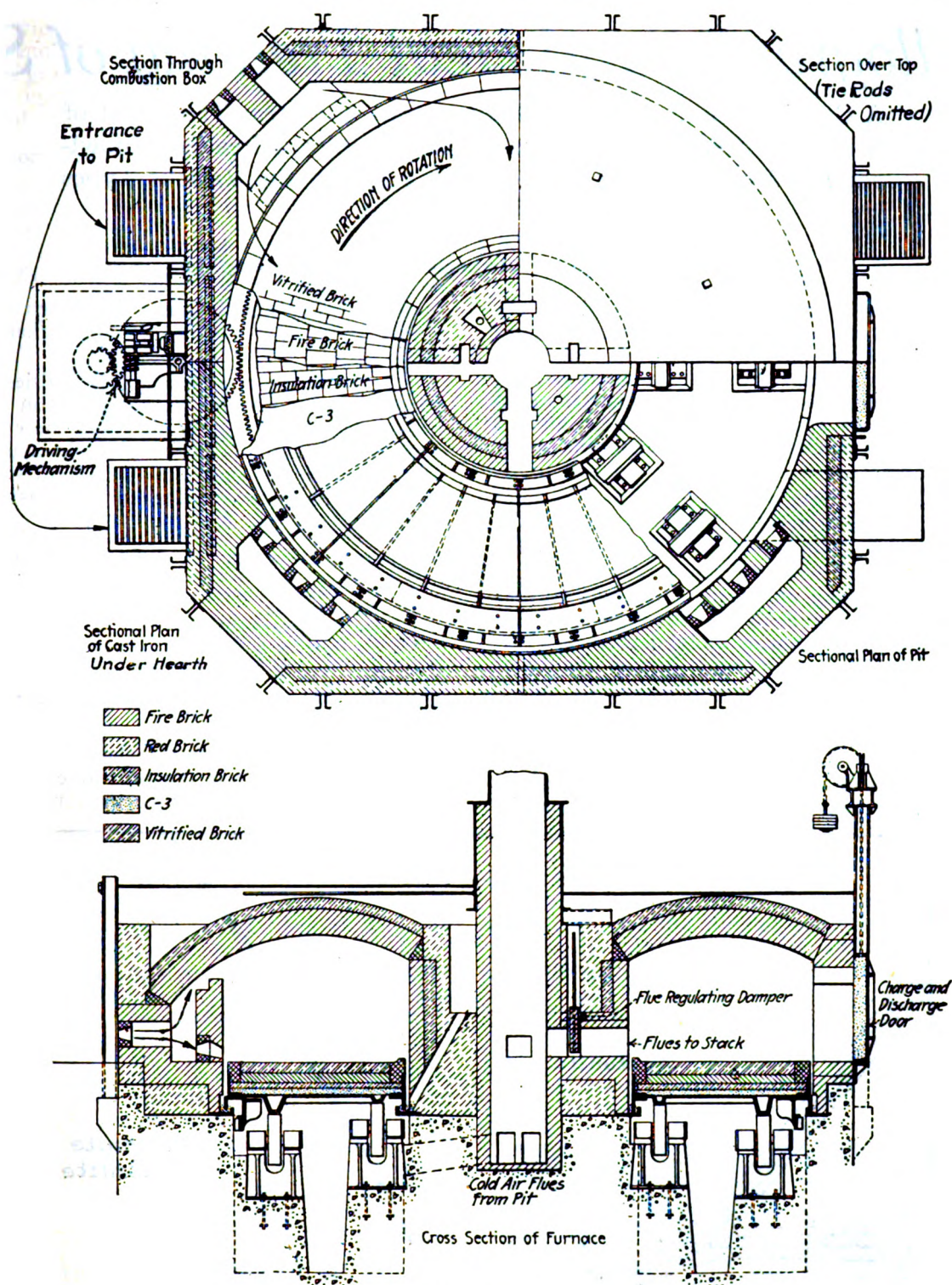


Fig. 197.

sequence, the power which is required to propel the hearth is almost negligible. It is, of course, just as easy to design the hearth for one revolution per hour or for even a shorter time.

Compared to in-and-out furnaces in the same plant, the rotating hearth furnace showed 100 per cent increase of production for a given floor space; 45 per cent saving in labor; 20 per cent saving in fuel. The saving of labor is quite noticeable.*

The furnace in question has been described at some length, with the intention of dispelling the notion that large furnaces with rotating hearths are bound to fail. What may be stated positively is that they

require more care and experience, both in design and in erection, than furnaces with stationary hearths.

The rotating hearth furnace does not readily lend itself to being used as a muffle furnace, on account of the inaccessibility of the interior of the muffle at the door, unless a disproportionately large part of the circumference is sacrificed for the door. It is very well adapted to being used in conjunction with electric resistors. Such a furnace was shown in Fig. 95, part 13.

The limit of temperature for heating steel on rotating hearths lies at about 2,200 degrees F. At higher temperatures, there exists the possibility of forming slag and having it run into the sand seal slot, which fact would introduce complications.

Metallography and Heat Treating of Steels

A Concise Treatise on the Metallography and Heat Treatment of Steel—Written for the Purpose of Refreshing the Readers Knowledge of Metallography and Reviewing Briefly the Various Types of Heat Treatment.

By WM. J. MERTEN,
Metallurgical Engineer, Westinghouse Electric & Mfg. Co.

THE selective heat treatment of steel and the accompanying beneficial changes in physical properties of the material enabling it to resist the stresses peculiar to the specific application in service, becomes more generally known to the industrial world and naturally creates a demand for a better quality product in parts of machinery, implements and other articles of commerce.

In other words we have arrived upon the threshold of an era where the engineer designer must differentiate as to the proper grain structure of the parts of the machine.

There is still among engineers a conception that the addition of alloying elements to steel such as nickel, chromium, vanadium or molybdenum will furnish all that is desired regarding a higher quality of material. The result of such practice was of course disappointing and failed to sustain such expectation and was not destined to be an impetus to the alloy steel industry.

These additions of alloying elements are beneficial only when proper heat treatment follows a careful

manufacturing practice, and only then is the reward a justification for the use of the higher priced alloy steel.

The tendency to overcome difficulties by the substitution of alloy steels for the common carbon steels, has also hindered and side tracked the employment of ordinary grades of carbon steels in a number of instances where a proper heat treatment would have resulted in their use to the entire satisfaction of the service.

Heat treating may be divided into distinct groups:

- a. Annealing
- b. Normalizing
- c. Double treatment
 1. Heating and quenching for hardening
 2. Heating for tempering.

Transformation Ranges or Heat Treating Temperatures.

When steel solidifies the change from the liquid to the solid state is not the only one occurring during cooling. Significant transformations in grain struc-

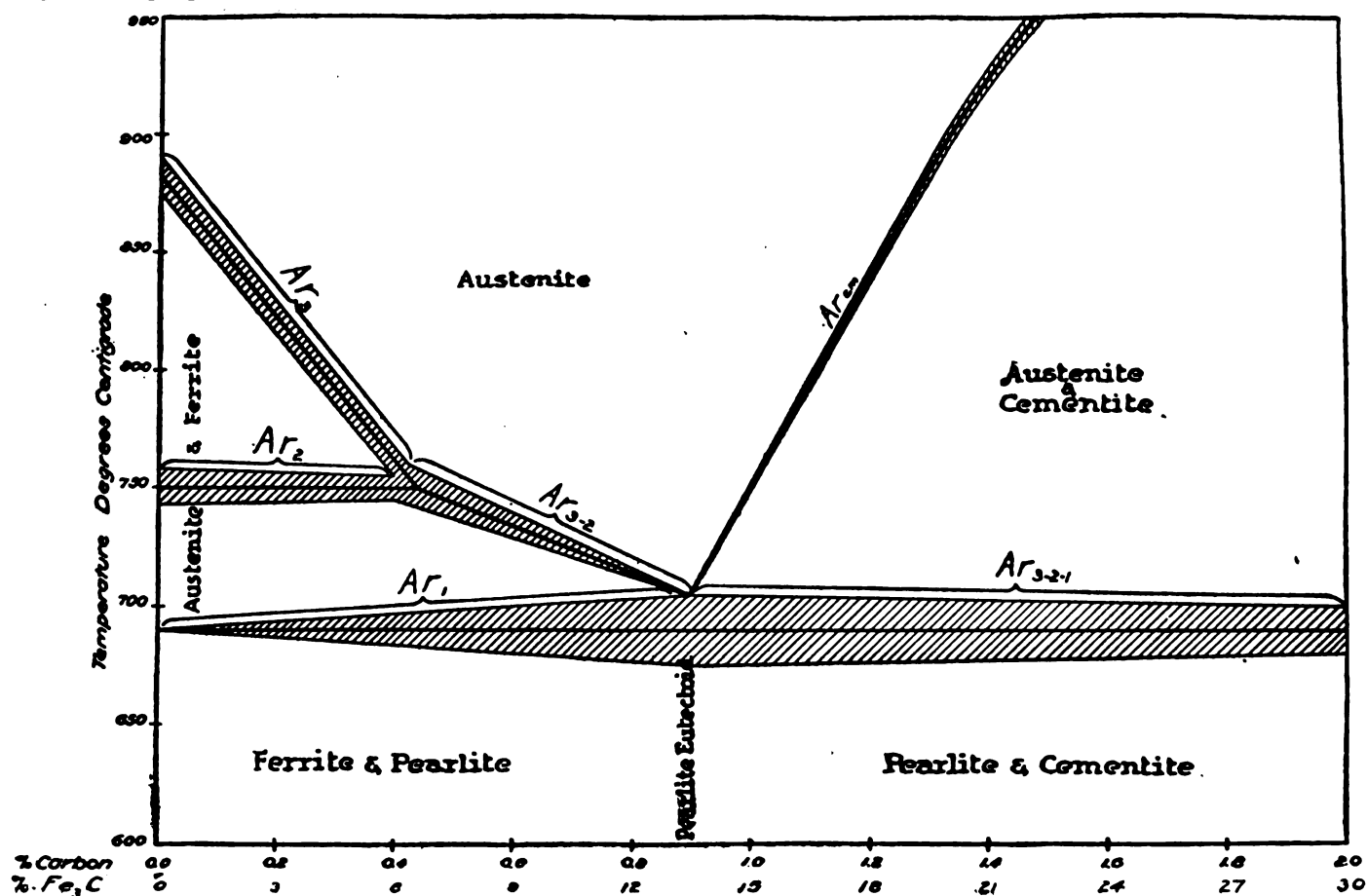


Fig. 1.

ture, while solid, with accompanying alterations in physical properties at sharply marked critical temperatures happen and are of great importance, since the modification of grain structure by judicious heat treatment depends upon these transformations at the respective critical temperatures.

For Low Carbon Steel.

Low carbon steel at high temperatures represents isomorphous mixtures (solid solution) of gamma iron and of carbon.

On cooling to approximately 900 degrees C. (1,650 degrees F.) beta iron precipitates, until the whole mass has cooled to 760 degrees C. (1,390 degrees F.) when this beta ferrite changes to the alpha form and all additional precipitated iron from the solid solution is alpha ferrite, until it reaches 700 degrees C. when all alpha ferrite has precipitated and the isomorphous mixture of iron and carbon has reached the eutectic ratio or contains approximately 89 per cent carbon, no further change or modification occurs below this temperature. These changes are reversible or they taken place on heating as well as on cooling. To designate the temperatures at which transformation occurs, the letters A_1 , A_2 and A_3 are commonly used, A_1 at approximately 700 degrees C., is the point at which steel acquires hardening properties on heating and loses the properties on cooling, and is due to the presence of carbon.

A_2 occurs at approximately 760 degrees C., and this symbol designates the temperature at which alpha iron, which exists at ordinary temperatures, changes to beta iron. Alpha iron is non-magnetic, a poor conductor of electricity, has a different specific heat, etc., than an ordinary iron.

A_3 is the point of change from beta iron to gamma iron and happens near 900 degrees C. for low carbon steels. Gamma iron is non-magnetic, dissolves carbon readily and forms a solid solution with carbon. To distinguish these three points on heating or on cooling they are designated by Ac_1 , Ac_2 , Ac_3 , from the French C for (Chauffage-heating) and Ar_1 , Ar_2 , Ar_3 , from the French "R" for (refroidissement-cooling).

Properties of Alpha, Beta and Gamma Iron.

Alpha iron which exists up to 760 degrees C. is magnetic, it will not dissolve carbon, alpha iron is soft and ductile. Beta iron, which exists from 760 to 900 degrees C. is non-magnetic, it does not dissolve carbon or only to a very slight extent, and will not form twin crystals.

Gamma iron is non-magnetic, it will readily absorb carbon and forms twin crystals, gamma iron is hard.

The knowledge of these properties of the three allotropic forms of iron is of great importance for the intelligent conductance of certain heat treating processes, e. g., carburizing or case hardening of low carbon steels.

Medium Carbon Steels.

Steel of about 45 per cent carbon has only two critical points, namely, the Ac_1 point at 700 degrees C.; and Ac_{32} point at 760 degrees C. The upper point Ac_3 having been lowered by the higher percentage of carbon until at about .40 per cent carbon it coincides with Ac_2 , this is, therefore, the natural subdivision for low and medium carbon steels and the range for medium carbon steels is accordingly from the merging point of Ac_{32} .40 per cent carbon to the point just below eutectic steel .89 per cent carbon.

Eutectic and Higher Carbon Steels.

Raising the carbon contents above .40 per cent in steel gradually lowers the Ac_{32} point until the eutectic ratio of .89 per cent carbon is reached, when Ac_{32} will coincide with Ac_1 , indicating that eutectic steel has only one transformation temperature at 700 degrees C. where the solid solution breaks up into alpha iron and iron carbide Fe_3C (cementite). All steels of a higher carbon range than .89 per cent and up to 2.00 per cent have a Ac_{321} point at nearly 700 degrees C. which represents the carbide change. There is, however, another transformation point which is shown in diagram Fig. 1, on the Ar_{cm} line and is the temperature at which free cementite Fe_3C is deposited on cooling.

Alloy Steels.

Alloy steels are defined as steels which owe their properties mainly to the presence of an element or elements other than carbon, and we have in accordance with the above the following alloy steels: nickel steel, chrome steels, nickel chrome steels, vanadium steel, chrome vanadium steels, tungsten steels, molybdenum steels, manganese steels, etc. The influence of these alloying elements is to lower the position of the critical ranges. In special cases this transformation range is lowered to and below ordinary temperatures, and the steel is then a self hardening steel (mushet steel). High speed steels in which chromium, tungsten and vanadium are the alloying elements, are when cooled quickly austenitic-martensitic and are relatively stable up to approximately 500 degrees C. and tools from such steels retain their edge at visibly red heat. To effectively dissolve the free carbide, a white heat of (1,260 degrees C.) 2,250 degrees F. to (1,290 degrees C.) 2,350 degrees F. is necessary and a rapid cooling by air blast to prevent the freeing of the cementite may be used for hardening.

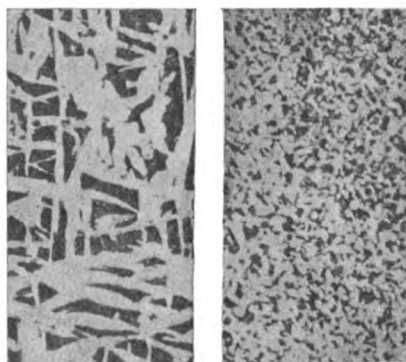


Fig. 2—Steel cast—Fig. 3—Casting an-
ing—Not annealed nealed

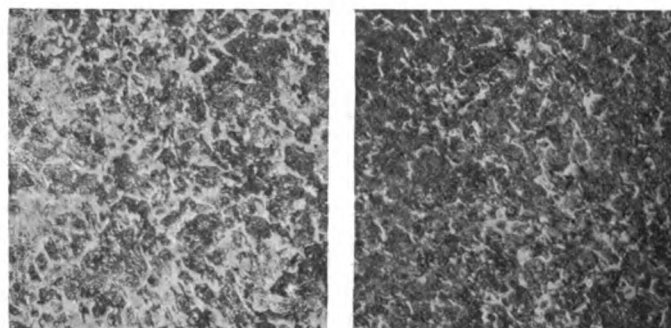


Fig. 4—Forging cooled from
a high forging heat

Fig. 5—Forging annealed

In the above sections steel was classed as low carbon, medium carbon, eutectic and higher carbon steels. With reference to the position and number of the transformation points, it is however more practical

to classify with reference to the percentage of carbon it contains and its consequent position with respect to the eutectic alloy, and we know according to this nomenclature hypo-eutectic steel (steel under .89 per cent carbon) eutectoid steel—steel containing .89 per cent carbon and hyper-eutectoid—over .89 per cent carbon.

Micro Structure of Annealed Steel.

Strictly speaking ferrite and cementite are the only definite constituents of annealed carbon steels. Ferrite being the name applied to the alpha iron and is the white constituent in micrograph 2 and 3.

Cementite or carbide of iron Fe_3C is a definite chemical compound of iron and carbon. Pearlite, the dark areas in micrograph 2 and 3 is not a simple constituent, but is made up of lamellae of ferrite and cementite and gets its name from the pearly appearance when etched. Pearlite contains .89 per cent carbon. Eutectoid steel in the annealed state is therefore all pearlite.

Micro Structure of Heat Treated Steels.

Steel above its upper critical range is composed entirely of austenite or gamma iron, as illustrated graphically in Fig. 1, and upon cooling slowly it will contain ferrite and pearlite or pearlite and cementite depending upon the percentage of carbon in the steel. In passing through the transformation ranges a series of transition constituents are formed. These are in the order of cooling—martensite, troostite, sorbite. Austenite is the solid solution of carbide of iron (Fe_3C) in gamma iron. Partly austenitic steel has been obtained by quenching carbon steels of over 1 per cent carbon from 1,000 degrees C., it etches white on a polished surface and exists above the Ac_3 point in all steel.

Martensite is obtained by quenching steel from above the upper recalescence point, when the whole of the cementite is in solid solution. The etched surface shows the interlacing at an angle of 60 degrees.

Martensite is extremely hard and scratches quartz. Martensite is magnetic. In martensite the iron is in the beta form. Troostite is a constituent resulting from the transformation of martensite and is encountered in all steels of .50 per cent and more carbon where the cooling has not been too rapid through the upper range, as in oil quenching, hot water quenching and tempered steels.

Troostite is softer and more ductile than martensite, at about 400 degrees C. it changes readily into sorbite. In troostite the iron is in the beta condition. Sorbite is, correctly speaking, not a constituent of hardened steel, but results from the transformation of troostite on tempering quenched steel at 400 degrees C. and higher. It is harder and considerably stronger than pearlite, and is the constituent which gives steel its highest impact resisting values, and its presence is wanted for fatigue resisting properties in materials subjected to shock and vibratory stresses. In sorbite also, the iron is beta iron.

Heat Treating Practice.

In general, annealing is conducted to improve and modify the grain structure or impart physical properties desirable and quite often necessary prior to the following step or steps in the cycle of operations preparatory to the service application of the steel.

1. Steel Castings in their raw state have a coarse and heterogeneous structure, and are annealed for refinement of this structure and homogeneity. 2. Forgings cooling slowly from a high finishing temperature are refined from the resulting grain growth by annealing. 3. Wire and other cold rolled cold drawn and cold pressed and formed materials are annealed for intermittent operations to relieve internal strains and impart ductility. 4. Tool steels are annealed to distribute the excess carbide of iron (Fe_3C) through the softer matrix of pearlite, thereby facilitating machining operations.

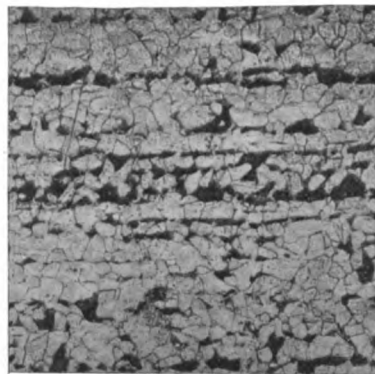
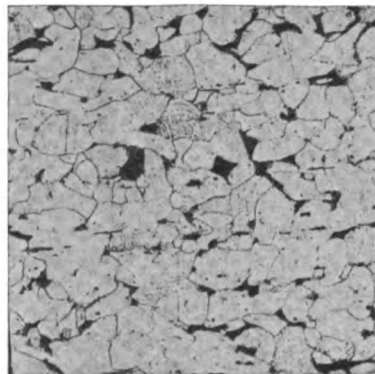
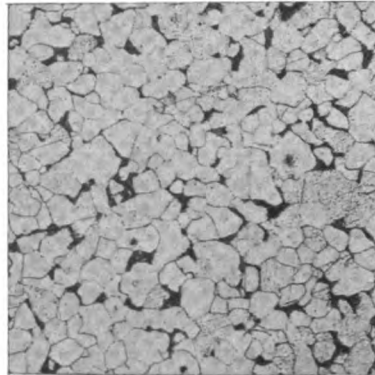


Fig. 6—Hot rolled steel cooled from a high finishing heat
Fig. 8—Cold rolled steel untreated
Fig. 10—Screw stock untreated

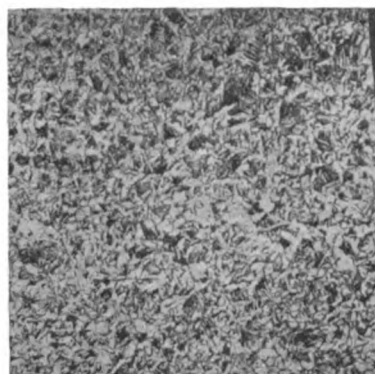
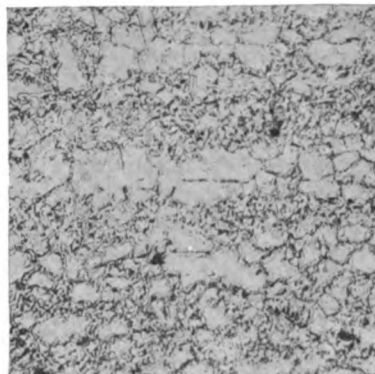
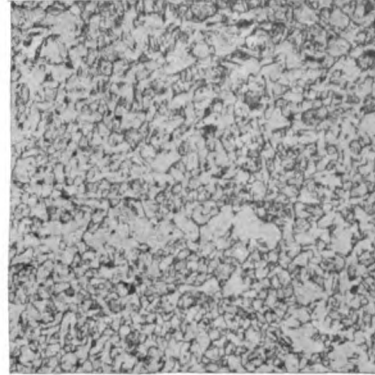


Fig. 7—Hot rolled steel annealed
Fig. 9—Cold rolled steel annealed
Fig. 11—Screw stock annealed

Annealing Processes.

The annealing operation consists of

1. Heating the steel uniformly to the proper temperature.
2. Soaking it at this temperature to assure complete penetration.
3. Cooling until color disappears or to a black heat.

Annealing of Steel Castings.

The coarse structure of steel castings is not refined at temperatures slightly above the upper critical range, a considerably higher temperature is necessary to break down this coarse grain. It has been the writer's experience that the higher the temperature of the metal when poured into the mold, the higher the annealing temperature has to be. Similar castings were made, one from a ladle about 60 seconds hot, (determined by measuring the freezing of liquid steel in a 4-inch diam semispherical ladle) and had to be heated to 1,825 degrees F. to refine the structure, while the other which was cast from a ladle 48 seconds hot, annealed at 1,700 degrees F.

Casting No. 1 was a	Casting No. 2 was a
.15 Carbon Steel	.17 Carbon Steel
.60 Mang.	.58 Mang.
.30 Silicon	.25 Silicon
.045 Sulphur	.035 Sulphur
.030 Phosph.	.025 Phosph.

The reason for this exceptional coarse grain structure is to be sought in the slow cooling of the mass after solidification through the critical transformation range A_3 to A_1 and the consequent grain growth as compared with the other steel, the mold having to dissipate this extra amount of heat and to break up this structure a considerable higher temperature is needed.

An illustration of the grain structure of a casting as cast and after annealing is given in photo micrograph 2 and 3.

Forgings, hot rolled steel plates and bars finished below the lower critical point are strained and must

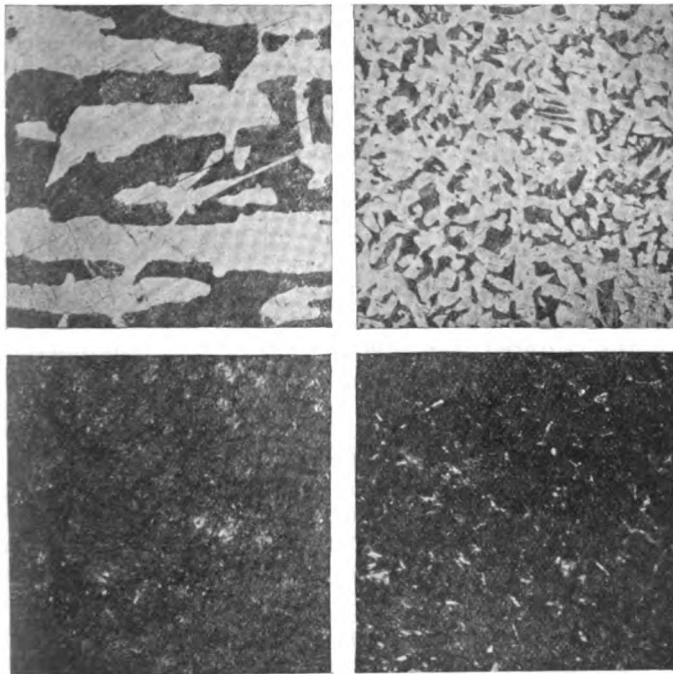


Fig. 12—Hot rolled plate cooled slowly from about 1700°

Fig. 13—Hot rolled plate normalized

Fig. 14—Die block as quenched

Fig. 15—Same die block tempered

be annealed before machining. This is accomplished by heating through the critical range and holding at this temperature, micrograph 4 and 5, to complete refinement of the elongated and banded ferrite and pearlite grains.

Cold rolled and cold pressed sheets, tubes, bars, etc., are annealed to relieve strains and increase ductility. A dull red heat of about 1,300 degrees F. will effect these results. In the above cases air cooling avoiding draft can be resorted to, Figs. 5, 6, 7 and 8.

The annealing of tool steels presents a quite different problem, low and medium carbon steels are heated to the proper annealing temperatures and then left to cool without extraordinary precaution regarding the character of the heating flame whether it be neutral or reducing. When annealing tool steel it is quite evident that the atmospheric condition in the heating chamber should be neutral or slightly reducing, since scaling or oxidizing, however slight, is causing a skin decarbonization which may seriously effect the usefulness of the tool. To provide this reducing atmosphere, a handful of charcoal thrown into the firing or heating chamber, with a well regulated burner to provide the proper air and fuel mixture for combustion will be very beneficial, even in an electrically heated furnace this charcoal addition is quite helpful. A very slow cooling from the annealing heat in the furnace chamber is another feature of tool steel annealing quite essential. Heat to about 1,400 degrees F. and soak just as long as it is necessary to uniformly heat the steel throughout, then turn off the heat and cool down while in closed furnace or transfer the tool from the fire and bury in lime, dry ashes or powdered mica.

Range of Annealing Temperatures.

Up to .15 per cent carbon, 875 to 925 degrees C., 1600 to 1700 degrees F.

.15 to .30 per cent carbon, 840 to 870 degrees C., 1550 to 1600 degrees F.

.30 to .50 per cent carbon, 815 to 840 degrees C., 1500 to 1550 degrees F.

.50 to 1.00 per cent carbon, 790 to 815 degrees C., 1450 to 1500 degrees F.

The following are precautions which should be kept in mind on annealing:

1. A proper fuel and air mixture is essential for best annealing results.
2. A white heat opens the grain and retards refining of structure.
3. A cherry red heat for tool steel annealing is a safe heat.
4. While steel cannot be burned in the true sense of the word until a blistering heat is obtained, steel can be disintegrated by soaking at temperatures considerable above the A_c point, and much soaking and disintegration is injurious to steel.
5. Non-uniform heating is responsible for many errors.

Normalizing.

Normalizing, as distinguished from ordinary annealing, produces a finer grain structure, due to the accelerated rate of cooling through the critical transition ranges by cold air currents, it produces a steel of considerably higher physical properties because of this fine structure. The treatment being equivalent to an airquench. The refinement or breaking down of a coarse structure is best accomplished at a fairly high temperature. The temperature between the A_{c3} and A_{c1} points are the most favorable ones for grain growth, and a holding or soaking in this range results in a dangerous crystal growth. There are several means of procuring this result; the first is a long time

heating just at or very slightly above the A_{c_3} or upper critical range, and soaking at this heat long enough for complete refinement followed by air cooling. The other is to heat sufficiently above the A_{c_3} point to refine fairly rapidly and then cool quickly in air.

Soaking at low heats just above the A_{c_3} or upper critical range gives doubtful results since the time limit for complete refinement is difficult to determine while heating to higher temperatures considerably above the A_{c_3} range obviates this uncertainty. Fig. 12 and 13 shows the change in structure due to normalizing, and Table 1 gives physical properties before and after normalizing of plates, $2\frac{3}{4}$ -inch thickness, 60 inches diameter of a .25-.30 per cent carbon O. H. steel.

Table 1.

	Limit Elastic	Point Yield	Tens. Ult.	E. Long %	Area % Red
Before	17500	21750	62850	21.2	34.8
After	22500	30825	65650	29.7	49.2
Before	11500	23400	62400	28.1	48.6
After	25000	31750	62350	31.8	51.1
Before	9000	21750	62000	31.5	48.9
After	22500	30900	62000	29.1	59.6
Before	15000	22750	64500	17.4	33.1
After	20500	31225	65900	28.9	49.7
Before	16800	22015	57500	29.9	50.0
After	26000	32500	62075	29.7	48.9
Before	16500	22000	58000	29.9	50.0
After	20000	25500	60350	22.2	53.0

The above plates were heated in a cartype side and overfired gas furnace, to 1,700 degrees F., pulled from the furnace after soaking at this temperature $\frac{3}{4}$ hours and left to cool in air.

The water or oil quenching of very low carbon steels which are too soft to allow a finishing machining operation, while not strictly speaking a normalizing treatment are best mentioned under this heading. The steel in the ordinary hot rolled or annealed form, exhibits a torn and ragged surface when machined with ordinary cutting tools, the water or oil quench renders it less plastic and it will then machine properly, presenting a smooth surface. Normalizing at the present date is a treatment not generally applied, but it is quite obvious that proper normalizing of castings, plates, shafts and other steel members and parts of machinery and motors will greatly increase the factor of safety over a green and untreated part, and must consequently become a standard practice.

Double Treatment of Steel, Heating and Quenching for Hardening.

As stated above steels of a low carbon range up to .30 per cent carbon do not harden appreciably when quenched in oil or water. The steels considered under this heading are therefore of a higher carbon per cent, not less than .45 per cent carbon. To harden such steel or generally any steel it is first necessary to heat it uniformly to and above its $A_{c_{321}}$ range. In other words, heat to formation of solid solution to secure fine grain structure and maximum hardness, cool it quickly from just above this range by quenching it in a cooling medium, which may be water, oil, brine or sulphuric acid, depending upon the structure desired. The resultant hardness varying directly with the rapidity of heat abstraction from the cooling steel by the quenching medium. Quenching should always be done on a rising heat, and since the location of the most desirable quenching temperature varies with the composition of the steel, this temperature must be de-

termined and known to get maximum hardness. Higher carbon means a greater increase in hardness. Heating for hardening must be gradual and uniform, avoiding any sudden and local heating. Never put cold steel for hardening in bright red hot furnace.

Quenching or cooling for hardening must be uniform and rapid, the speed of cooling depending upon the nature and quantity of the liquid and the mass of the piece of steel. Mass of steel and quantity of liquid being constant the speed of cooling or of heat abstraction varies with the quenching medium in the order given: sulphuric acid, highest, next is brine, then ice-water, light oil, heavy oil. Air is slowest. For the most effective temperature range of these quenching liquids. See Paper by T. F. Lynch and W. B. Pilling, "Cooling Properties of Technical Quenching Liquids," A. I. M. & M. E., Sept., 1919.

Heating for Tempering.

The purpose of the tempering of steel is to modify the degree of hardness and to relieve the hardening strains. In tools where extreme hardness is wanted, and the quenching has been sufficiently rapid to retain the steel in the martensitic condition it is very important that the severe strains in it be relieved immediately after hardening to avoid the breaking of the tool, although a temperature not higher than 200 degrees C. need be applied to accomplish the desired result.

The temperature at which tempering is to be conducted depends upon the quality of the steel and the service application for which it is intended.

This tempering lowers the hardness, reduces brittleness and increases toughness and ductility.

The following tempering processes are in common use:

Air tempering of tools, watch springs, etc., consists in heating the steel in air, and then watching the progressive development of the colors on a brightened surface of the tool. Color series commonly used: First, bright or pale yellow, 220 degrees C., darkening into a light brown, 250 degrees C., dark brown, 270 degrees C., purple, 285 degrees C., and lastly blue, 310 degrees C., which finally changes into black, when the steel, if a tool requires rehardening.

Oil tempering is a very reliable method and is applied to intricate dies and fine tools. All danger of overheating is avoided. When still higher temperatures are required, tempering in salt bath and lead pots is resorted to.

Tempering of shafts, large dies and materials of large masses, where temperatures of 500-600 degrees C. are required, the low heated furnace chamber is the best and most convenient place for this operation.

Fig. 14 and 15 shows a die steel quenched from 825 degrees C. in water, and tempered at 350 degrees in furnace, the structure is troostitic.

Tempering for modification of hardness begins at about 200 degrees C., and hardness decreases very gradually up to approximately 400 degrees C., when a marked softening takes place, this softening continues at this rate until the steel is fully tempered.

It should be understood that for all temperature determination, except for air tempering, pyrometers must be used. For specific heat treatment of special steels, reference to the tables of heat treatment. Specifications of American Society of Automotive Engineers is Advised.

FOREIGN RELATIONS

RECONSTRUCTING FRENCH CHEMICAL INDUSTRY.

By A. E. HARTZELL.

France has made notable progress in setting her chemical industry on its feet again. Although only 17 per cent of the chemical plants of all kinds in France were located in the devastated departments these plants were almost entirely destroyed. The departments of the Nord and of the Aisne suffered particularly, supporting 70 per cent of the total damage, which is estimated according to 1914 values to be 128,840,208 francs.

The Ministry of Liberated Regions, which has taken a census of the various plants that can be classed under the heading "chemical industry", announces that on October 1, 1911 out of 142, or 78.1 per cent had resumed operation wholly or in part. The greatest proportion in resumption of operation is found in the Lille region—89.3 per cent.

These 142 plants employed in 1914, 21,210 workmen. On October 1, 54.2 per cent of this number, or 11,512 were employed in production. The nearest approach to normal is found in the Department of the Meurthe et Moselle. A year ago, or on October 1, 1919, only 18.7 per cent of the 1914 personnel was occupied at production. Since that date there has been a steady increase, the proportion from January 1, 1920 increasing from 34.7 per cent to the 54.2 per cent mentioned above.

The production in 1914 of the plants which can be classed under the heading chemical industry proper, was estimated at 850,000 tons. The present production is between 200,000 and 300,000 tons. Under this heading are included plants manufacturing sulphuric acid, nitric acid, chlorohydric acid, sulphates of sodium, iron, copper, sulphites, superphosphates, ammonial salts and various fertilizers. No figures are yet available on the production of chemical by-product factories, either for 1914 or at present. Under this heading are classed all factories which handle chemical products already prepared, such as salt refineries, the preparation of crystals of sodium, hypochlorites, pharmaceutical and hygienic products, photographic materials, etc.

The chemical industry in general throughout France has received great encouragement as a result of the war. Prior to 1914 the industry was of relatively minor importance, French manufacturers preferring to import the necessary supplies from Germany, which for years had specialized in this branch of industry. However, once the German supplies were cut off and the war showed the immense value of chemicals in the successful prosecution of hostilities, the French government and private enterprises began to turn their attention seriously to the development of the industry in France.

The manufacture of powder, which is an important branch of the industry, is in the hands of the government, it being with tobacco, matches, etc. a government monopoly. It will only be necessary to cite a few figures on this one product to show what preeminence the chemical industry attained in the eyes of the French General Staff. The plan of French mobilization in 1914 included the following estimates:

Quantity of powder to be produced during the war—24 tons a day.

Quantity of other explosives to be produced during the war—none.

No one then supposed that the quantity of explosives on hand would not be sufficient for any war purposes. However, after the first battle of the Marne, the pressing need of chemicals for powder and explosives began to develop. It was necessary to create factories almost over night to meet the over-growing demands of the army. The original provisions, cited above, were doubled many times over so that by June 25, 1917, the estimates of army needs were the following:

Quantity of powder to be produced—640 tons a day.

Quantity of other explosives to be produced—1,100 tons a day.

All this productive capacity, no longer needed for war purposes, can be utilized to build up the chemical industry to a position where France will be independent of foreign sources of supply.

In this connection it is interesting to call attention to a recent French invention which simplifies the process of obtaining nitrates from the air, of which the Germans made so much during the war. The inventor is Georges Claude, the celebrated physician to whom France owes the creation of the liquid air industry. With a much smaller apparatus than that used in Germany, M. Claude is now able to produce a ton and a half of ammonia a day, which corresponds to seven tons of ammonia sulphate. The invention is of great importance because it will facilitate the production of ammonium chloride, greatly needed as a fertilizer by French agriculture.

BROKEN HILL COMPANY TO MAKE EXTENSIONS.

New castle, N. S. W., Australia—The Broken Hill Proprietary Company is about to raise £3,500,000 for new work. It is intended to increase the output of the rolling mills to 90,000 tons annually. Another blast furnace with a capacity of 500 tons daily is being built, together with a by-product recovery plant. In 1920 the dividends paid amounted to £315,000. The company's steelworks in Newcastle to date have produced 637,000 tons of pig iron. The coke ovens number 65 and have produced 624,000 tons of coke.

The output of the iron and steel works of the company in Newcastle, in the four weeks ending September 15, was as follows: 22,510 tons of coke, 262,000 gallons of tar and 294 tons of sulphate of ammonia; 10,481 tons of foundry pig iron, 13,000 tons of basic and 391 tons of ferromanganese; 21,000 tons of open-hearth steel; 20,485 tons of billets, and 351 tons of castings.

A large plant is being built in Newcastle for Ryland Bros., of Warrington, Lancashire, England, for the manufacture of wire netting. The site comprises 15 acres.

The federal government has increased the reward from £10,000 to £50,000 for the discovery of payable oil lands in Australia.

PRODUCTION TOPICS

SELAS SYSTEM OF INDUSTRIAL GAS UTILIZATION.

It is generally conceded that gas as a fuel for industrial purposes is far superior to any or all other fuels.

Until lately, the only argument that might be advanced against the use of gas in preference to the use of oil or coal for industrial fuel purposes has been that of higher costs. With the mounting prices of raw fuels and the increase in the efficient manufacture of gas, gas and other fuels have come closer together in price than ever before. The efficient utilization of gas has been the only thing necessary to bring gas as a fuel before practically all industrial plant managers.

Kinds of Gas.

The gases which may be used economically and efficiently for industrial purposes are as follows: Coke oven by-product gas, coal gas, carburetted water gas, blue water gas, and producer gas. Excepting for higher heats, all of these may be used efficiently under most conditions. Industrial plants have in the past depended entirely on the local gas company for gas for industrial heating purposes. With the advent, however, of blue water gas, it is possible for the industrial plant, if it finds it necessary, to build its own gas making unit and use it to a maximum efficiency through the use of the Selas system.

Coke oven gas, of course, is most cheaply used by those who are located near coke ovens, or are an integral part of a plant owning coke ovens. Coal gas and carburetted water gas are usually sold by local gas companies through their main system on a sliding scale of industrial rates based on consumption per month or maximum demand. Blue water gas and producer gas are primarily obtained through privately owned installations and make the industrial user free from dependency on others for his gas fuel.

Theory of Gas Combustion.

In the burning of any gas for its maximum heat value, which is after all what is desired, air must be mixed with the gas at some point before burning will take place. Depending on the amount of air, there will be either complete or incomplete combustion of the gas and air, materially affecting the heat value of the burning gases.

There are really only two kinds of heating installations; one in which a maximum of heat is desired irrespective of temperature regularity and the other where the maximum of heat is desired with the careful regulation of temperature. In the first instance may be classed such installations as boilers and heaters of various kinds requiring no exact temperature control. In the other class may be placed heat treating furnaces and their like.

In order to secure the maximum results in both instances, the gas installation must be capable of burning every particle of gas to its ultimate products of combustion without the utilization of any excess oxygen unless an oxidizing atmosphere is preferred. Whenever any system accomplishes these results, it may be called a system for efficient gas utilization and will demonstrate by actual measurements of performance before and after it is installed that it has effected a considerable saving in the amount of gas used for a given process.

Necessary Controls.

In order to make such a system efficient, there are three

things necessary; one, there must be a control over the mixture of gas and air so that at all times, irrespective of the amount of gas used, the ratio of gas to air is exactly the same. Two, there must be a control of the mixture of the gas and air flowing to the heating element so that a constant temperature may be obtained whenever that is desirable. Three, there must be such a placement of the combustion zone that it will give up to the material heated, a maximum of the thermal value produced by the combustion of the gases.

Selas System.

All gas mixing apparatus and gas furnace equipment is designed with these factors primarily in view and the best combination is the one that gives the best results. The Selas System is composed of two essential things; one, engineering experience and two, gas burning equipment.

Into the analysis of any problem special engineering experience is necessary to determine what is the best solution for the given problem. It is very often possible to effect considerable economies by rearrangement of burners and by new types of burners simply by being able to pick out the weak points of any installation, but after such a survey is made the Selas System is able to, by means of its second part, to effect the savings and economies that the engineering experience has found necessary.

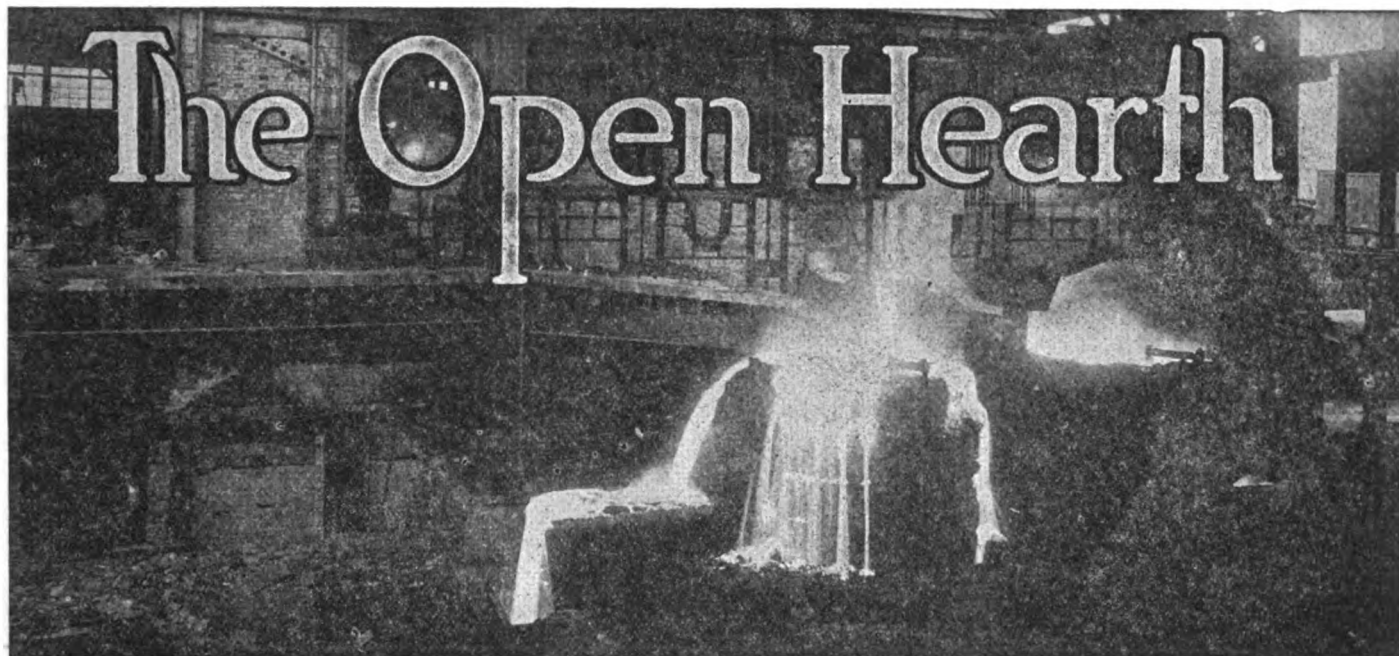
The Selas apparatus consists of a machine combining regulators, mixer and compressor and properly designed burners for the Selas mixture.

A governor into which the inlet gas is passed, reduces the pressure of the gas as it comes from the main or service to atmospheric conditions. This governor is carefully balanced and is extremely sensitive to variations in pressure. Beyond the governor is the mixer into which gas and air are both drawn at atmospheric conditions and thoroughly mixed. The upper portion of the mixer consists of a cylinder and piston with opposing port holes, two in each. On one side of the cylinder, air enters and on the opposing side, gas enters. By revolving the piston in the cylinder, the size of the gas and air ports may be varied so that different proportions of air and gas may be admitted at any given time.

The control of this piston is by means of a small lever set on top of the mixer attached to a rod passing through a stuffing box into the mixer chamber. It is therefore, possible to change the mixture of gas and air without opening up the machine while the machine is running.

The gas, after it enters into the upper portion of the mixer is sent to the bottom where it is thoroughly mixed. This mixture is then drawn out into the compressor and is raised to one or two pounds pressure as it is desired, and thus sent out to the burners. The burners are of the bunsen type and are specially constructed for the utilization of the premixed gas and air so that they will admit a sufficient amount of additional air necessary for complete combustion.

The principle of operation is simple. Gas is reduced to atmospheric pressure and admitted to the mixer. The air is secured at atmospheric pressure and admitted to the mixer. The proportions may vary from one to one, to one to three, one representing the amount of gas, and three representing the amount of air depending on the thermal value of the gas.



John N. Mowrey, Philadelphia, has been promoted to the position of general manager of the Worcester Pressed Steel Company, Worcester, Mass., effective January 1. Mr. Mowrey succeeds Donald C. Nickelson, resigned.

V V

Richard C. Lea has been transferred to manager of the Los Angeles branch of the Crucible Steel Co. of America. Mr. Lea was formerly manager of the Milwaukee branch of the same company.

V V

Joseph G. Butler, Jr., vice-president of the Briar Hill Steel Company, Youngstown, recently underwent a serious operation in the Youngstown City Hospital. His condition is regarded very satisfactory, according to the latest reports.

V V

Harvey Schilling has been promoted to the position of assistant superintendent of the rod and wire department of the Youngstown Sheet & Tube Co., Youngstown, Ohio. Mr. Schilling succeeds G. E. Mirfield, who has been assigned special work at the works office. Charles Knesal succeeds Mr. Schilling as secretary to W. C. Reilly, general superintendent.

V V

John W. Lees has recently been promoted to the position of vice-president in charge of operations of the Inland Steel Company, Indiana Harbor, Ind. Mr. Lees, who has been connected with the above named company for many years, and will have his headquarters at the Inland company's Chicago office. William A. Maxwell, formerly assistant general superintendent of the Cambria Steel Company, Johnstown, Pa., succeeds Mr. Lees as general superintendent.

V V

Harry S. Mulliken, who has been appointed metallurgical engineer, Bureau of Mines, Washington, is a graduate of the Worcester Polytechnic Institute, and well known throughout New England. He has been connected with a number of mining and metallurgical enterprises, as superintendent, lead smelter, Pilot Bay, British Columbia; superintendent, American Smelting & Refining Co., Aguas Calientes, and Monterey, Mexico; general superintendent and plant manager, Penoles Companies, Mapirni, Mexico; in charge of metallurgical operations of the American Metallurgical Company's interests in Mexico; and consulting engineer in metallurgy for the same company with offices in New York.

Richard W. Tull resigned his position as contracting manager of the Eastern Steel Company's New York Office, to become sales agent in New York, of the Montgomery Iron & Steel Co., Philadelphia. The office of this company has been removed from the Condlar Building to the Park Row Building. Mr. Tull is at present with his wife on a pleasure trip to the Pacific coast.

V V

W. G. Griffiths, who was formerly connected with the Crucible Steel Co. of America for about 18 years, has become assistant to the president of the Blaw-Knox Company, Pittsburgh, in charge of cost accounting.

V V

F. G. B. Allan has been promoted to the position of general manager of the Pressed Metals Co. of Canada, and the American Bushings Corporation, in succession to J. W. Leighton, who becomes chief engineer and supervisor of works.

V V

T. W. G. Wallace recently retired from the United States immigration service, at the port of Boston, where he had been connected with the Chinese department for a long time, to become associated with the United States Steel Corporation.

V V

Harry Badger, who has been superintendent of the Stanley Insulating Company, Great Barrington, Mass., for two years, will leave that position to accept a similar one with the Youngstown Pressed Steel Company, Warren, Ohio, effective December 20.

V V

Bertram D. Taitt has been promoted to the position of superintendent of the National works of the Wickwire-Spencer Steel Corporation, Worcester, Mass., to succeed James E. McKenny, who resigned to go with the Republic Rubber Corporation, Youngstown, Ohio. Charles H. Keenan, formerly auditor of the Wickwire Spencer Corporation, has accepted a position as head of the cost department of the Republic Rubber Corporation, Youngstown, Ohio.

V V

Charles M. Reed, formerly assistant to the steam engineer of the American Sheet & Tinplate Co., Pittsburgh, has become power engineer for the Portsmouth Cotton Oil Refining Corporation, Portsmouth, Virginia.



F. K. Fawcett has resigned his position as purchasing agent of the Universal Steel Company, Bridgeville, Pa., to become vice-president and general manager of the Zahniser Mfg. Company, Washington, Pa. Mr. Fawcett was connected with the Universal Steel Company for five years in the capacity of purchasing agent.

V V

Thomas B. Wilson, formerly engineer of the Cambria Steel Company, has been appointed chief steam engineer at the plant of the Bethlehem Steel Company, Sparrows Point, Maryland.

V V

Albert C. Mann, formerly vice-president in charge of purchases of International Steel Corporation, 51 Chambers street, New York, has resigned to become vice-president of the Illinois Central Railroad, including the Yazoo & Mississippi Valley Railroad, with headquarters at Chicago. Wayne Mendell, assistant to the president, has been appointed vice-president and general manager, and Peter C. Mayer, who has been a member of the purchasing department for three years, and was Mr. Mann's assistant, becomes purchasing agent. Morris Metcalf is president of the International Steel Corporation, which is one of the American International group. Mr. Mendell, who as vice-president and general manager, now assumes direct charge over all the activities of the business, was born in Moran, Kan., December 22, 1886. In 1905 he established a business of his own in the oil district, which business he operated successfully for 10 years. He came to New York in 1916, entered the export trade and became associated with the International Steel Corporation two years ago.

V V

The Crucible Steel Company have recently organized and elected the following officers: Horace S. Wilkinson, chairman; Dr. John A. Mathews, president; George E. Shaw, vice-president and treasurer; Gilbert M. Black, vice-president in charge of operations; F. B. Hufnagel, vice-president; J. M. McComb, vice-president in charge of credits; R. H. Illingworth, vice-president; W. R. Joralemon, secretary and assistant treasurer; H. F. Kress, assistant secretary and treasurer; H. L. Gellinger, auditor; and D. C. Barry, comptroller. Dr. John A. Mathews, who moves up from the position of

vice-president of the company to the presidency, has been with the company since 1902.

V V

F. B. Hufnagel, president Pittsburgh Crucible Steel Company, a subsidiary of the Crucible Steel Co. of America, who has been elected vice-president and director of the latter, is a graduate of Cornell University. For the past 20 years he had been connected with the Jones & Laughlin Steel Company, Pittsburgh, and before that, for a brief period, following his graduation from Cornell, had been with the Newburgh works of the American Steel & Wire Co., in Cleveland. Starting as a member of the engineering staff of the South Side Works of the Jones & Laughlin Steel Co., he advanced through the rolling mill department until he became general superintendent of that works. In 1912 he was transferred to the Alliquippa works of that company, in Woodlawn, Pa., in the capacity of general superintendent and remained in that position until about a month ago, when he resigned to become president of the Pittsburgh Crucible Steel Company.

V V

Henry W. Seldon has resigned from the Jones & Laughlin Steel Co. to take charge of the Service Department for the Amsler-Morton Company, Industrial Manufacturers and Contractors, Farmers Bank Building, Pittsburgh, Pa. Mr. Seldon is a graduate metallurgical engineer of Carnegie Institute of Technology and has spent six years in metallurgical and open hearth operating work with the Cambria Steel Company, Johnstown, in charge of gas producers, and three years with Jones & Laughlin Steel Co., Southside works, as an open hearth and gas producer efficiency engineer.

V V

William G. Bauman has been elected vice-president and general manager of the Tomahawk Iron & Steel Works, Tomahawk, Wis., succeeding F. J. Callan, who resigned.

V V

John H. Fulton has been elected a director in the Crucible Steel Co. of America, Pittsburgh. Mr. Fulton is affiliated with the National City Bank, New York.

V V

W. R. Shimer, sales metallurgist, of the Bethlehem Steel Company, spoke on "The Manufacture of Steel", before the Springfield, Mass., Chapter of the American Society for Steel Treathers, December 17.

INDUSTRIAL

GETTING RESULTS FROM PLANT SAFETY COMMITTEES.

By T. H. MCKENNY.

The topic assigned to me "Getting Results From Plant Safety Committees," presents to my mind a somewhat difficult problem to discuss, insofar as being able to say just exactly the best and most efficient method or plan to follow in order that the best results may be obtained, inasmuch as there are so many different plans of organization. I feel it is largely a matter of choice with the individual industry, the nature of the business itself, in many instances, determining the plan which would prove most effective and be best adapted to the particular industry in question. Therefore, in presenting my paper I will necessarily confine my remarks entirely to the organization and functioning of plant safety committees in the steel industry, my own experience having been gained in this field of endeavor.

I believe it is generally understood among the pioneers of the safety movement, that the first safety committee was organized in the South Works of the Illinois Steel Company, a subsidiary of the United States Steel Corporation. This committee was organized in the year 1908, and we feel that the formation of safety committees was one of the most important features inaugurated in the progress of organized safety work.

I have no doubt many of you are perfectly familiar with the plan of organization of the various safety committees of the United States Steel Corporation; however, for the benefit of those of our friends who may not be cognizant of same, it might be illuminating to take just a moment and touch briefly upon the organization and functions of the various committees of the United States Steel Corporation.

Organization—The Casualty Inspectors of the subsidiary companies were called together to discuss accident prevention in May, 1906, and the subsidiaries activity engaged in safety work by appointing special men for this purpose, the first committee of safety, as aforesaid, being organized in the year 1908, and the present line-up of these committees is as follows:

1. The United States Steel Corporation Committee of Safety—Consists of seven members of the larger subsidiaries, presided over by an officer of the steel corporation. This committee meets quarterly, its principal business being the study of all serious accidents and making recommendations as to the best means of preventing a recurrence. These recommendations of course, are passed along to all subsidiaries of the corporation.

2. Central Safety Committees—Made up of important officials of the various subsidiary companies. They meet monthly, and their duties are similar to those of the Corporation Committee, except that the field of activities covers their particular subsidiaries only.

3. Plant Safety Committees—made up of important officials of the individual plants. Meet monthly, weekly, or as often as occasion demands, with duties similar to those mentioned in the foregoing, except with reference to the particular plant only.

4. Departmental and Special Committees—The personnel

organization and functioning of our departmental and special committees, would be to select a typical standing committee, one which has accomplished good results and analyze its operation.

We have in one of the rolling units of our plant a committee whose personnel is comprised exclusively of foremen. In this department the field is divided into four divisions, each division representing one unit of that particular department, two committeemen being assigned to each division. The duties of this committee are to investigate general safety and sanitary conditions, and examine each employee as to his knowledge of safety rules. Should an employee not measure up in his knowledge of these rules he is requested to familiarize himself with all rules and regulations pertaining to safety and present himself at some near future date for re-examination. The committee meets twice each month, at which time reports covering their inspections are discussed, recommendations made as to the condition of their mills, and the superintendent or foreman of each particular unit is held responsible for its condition. All recommendations must be acted upon before the next regular meeting.

PLANTS

be equipped for structural steel production. Estimated to cost approximately \$75,000. W. C. Roxen

Commercial Shearing & Stamping Company, Youngs-ville, Ohio, affiliated with Carnick Brothers, will operate its new plant on Logan avenue, extensions for the manufacture of small size, blue annealed sheets, etc. The new building will be 81 x 600 feet, and will be supplemented by a number of smaller structures. The company has a total of 13 acres of land in this section to provide for future expansion. The installation at the new works will include shearing and shearing machinery and auxiliary equipment, with two 10-ton electric traveling cranes and a 20-ton magnet crane. The shearing department works will have an output of about 75 tons of sheet steel per month. The company was recently incorporated with a capital of \$50,000. Robert Carnick is president, and Robert Carnick is vice-president and manager.

The Steel Wheel Company, 40 Court street, Buffalo, N. Y., manufacturer of steel automobile wheels, etc., has awarded a building contract to the J. W. Hooper Construction Company, Buffalo, N. Y., for the construction of a new plant at North Tonawanda, N. Y. The new plant will be located on Nash Road, and is estimated to cost \$75,000.

The Steel Company, Seyfert, Pa., is planning for the construction of its new sheet and plate mill at Pottstown, Pa., in 1921. The plant, for the most part, will be devoted to the production of steel plates, annealed sheets, etc., and will include stack work. The company is arranging plans for the expansion and will soon file articles of incorporation under state laws. Other plants are now being planned at Seyfert and Glasgow, Pa., as well as at Rahway, N. J. J. W. Heydt and Edgar H. Heydt head the company.

The National Cold-Drawn Steel Company, National City, Cleveland, has acquired property on Dunham street, Cleveland, for the construction of a new plant, and plans for the construction of the works are now being prepared. The initial mill will comprise a main one-story building 160 x 400 feet and a number of subsidiary structures, and is estimated to cost about \$200,000 with machinery. It is understood that a list of equipment for installation will be arranged at an early date. W. W. Wallace is head.

The Rockford Sheet Steel Products Company, Rockford, Ill., recently incorporated with a capital of \$200,000, has arranged for the operation of a plant at Fourteen street and Fifth avenue, for the manufacture of sheet steel specialties of various kinds. The company is headed by R. D. Chappell, David Pizer and W. H. Hendrickson.

The Bates Expanded Steel Truss Company, 208 South LaSalle street, Chicago, Ill., manufacturer of steel poles, etc., for electric line service, has completed arrangements for the erection of a new addition to its plants on Forsythe avenue, East Chicago, Ill. The proposed structure will be one-story, 100 x 135 feet, and is estimated to cost about \$50,000. Frank C. Wall, East Chicago, is contractor.

Plans for the new works will be maintained along these same lines. It is reported that a number of improvements will be made in the works, but no extensive additions are contemplated at this time.

The Railway Steel Spring Company, 30 Church street, New York, has awarded a building contract to the McClintock-Marshall Company, 39 South Dearborn street, Chicago, for the erection of a new one-story plant at Chicago Heights, Ill., for general increased production. The structure will be used for an addition to the present plant at this location. It will be 70 x 160 feet, and is estimated to cost about \$50,000.

The Carolina Steel & Iron Co., Greensboro, N. C., has plans under way for the construction of its proposed new plant on local site, recently acquired, to comprise a number of units. The first unit will be one-story, steel 110 x 100

WITH THE EQUIPMENT MANUFACTURERS

A LARGE TRIMMING PRESS.

The following was received from the Toledo Machine Tool Company, Toledo, O.

The accompanying half-tone illustrates what we believe to be the largest single crank trimming press with side shear that has ever been built. The press has a number of special features which are worthy of note. The frame is of the four piece steel tie rod type of construction, which consists of a base, two uprights and a crown held together by four large steel tie rods which are shrunk into place. These four rods take the stress. The uprights are extra heavy to withstand any lateral stresses which might occur when the slide is unevenly loaded. Presses with this type of construction are capable of economically operating dies for the heaviest kind of work that can be done in presses. The twin gears on the main shaft are an original feature in a trimming press of this character, and it will be noted that the design is such as to make an entirely self-contained machine without any outboard bearings and with the main gears close up to the uprights of the press. The gearing, moreover, is mounted high on the frame and in no way interferes with the operator at the back of the press.

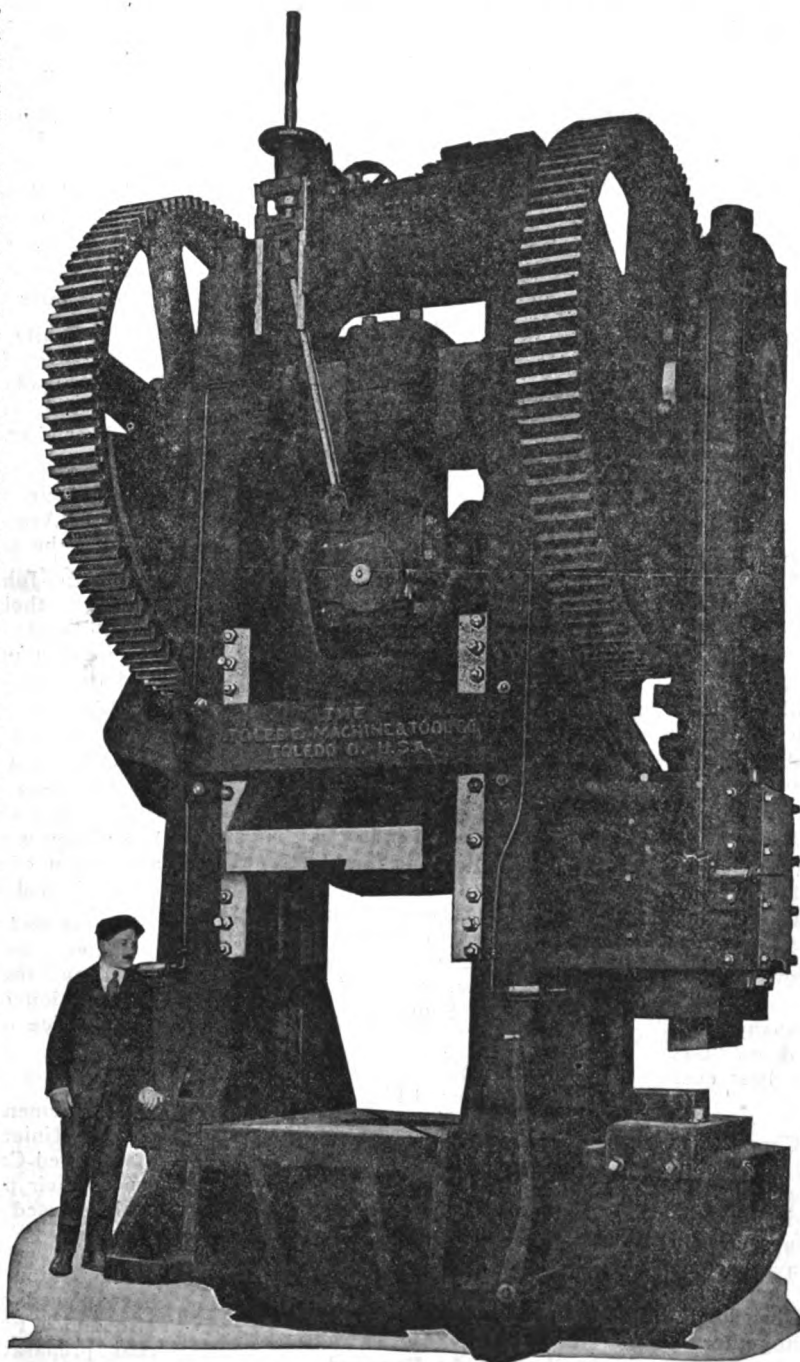
The outside shearing or cutting off slide is particularly massive and substantial. It is operated by an eccentric shaft which extends through the bearing in an auxiliary housing, secured to the outside slide housing by steel tie rods.

The press is controlled by a powerful hand actuated friction clutch which enables the operator to start or stop the machine at any point of the stroke. The slide is raised and lowered to the proper adjustment by a special power driven elevating device. This saves

considerable time when changing dies of varying heights. All of the main bearings are lubricated from the floor by a centralized forced feed lubricating system. The press is driven by a direct connected 50 hp motor mounted on a bracket at the rear of the machine.

The press is specially adapted for trimming crankshafts of 12-cylinder aeroplane engines, and it will readily trim other work of large dimensions which is forged in 15,000-lb. hammers or even larger.

An idea of the size of the press may be had from the following dimensions: Weight about 185,000 lbs.; area of slide flange F. to B. x R. to L. 68 x 40"; area of bed F. to B. x R. to L. 72 x 48"; standard stroke of slide 16"; distance bed to slide stroke down and adjustment up 30"; stroke of outer slide 6"; ratio of gearing 44.1; number of strokes per minute 7; extreme height over floor 229"; floor space over all F. to B. x R. to L. 137 x 166".



The frame is of the four piece steel tie rod type of construction, which consists of a base, two uprights and a crown held together by four large steel tie rods which are shrunk into place.

100-POUND WELDING MACHINE.

The Electric Cutting and Welding Co. has developed a welding machine weighing complete 100 pounds, which, with reasonable care, will accomplish any work in or around a garage or garage machine shop, etc., that is, the machine will use electrodes from 1/16" to 5/32" and will operate continuously with the medium and small sizes, and intermittently on the large size.

This machine will operate on either 110 or 220 volts, and any frequency specified in the order. There are two coils in series on 220 v and in multiple on 110 v. The power supply must be of at least 5 kva in order to use this machine, and be within the underwriters' regulation. While it will operate from a lamp socket with the smaller electrode, it is not allowable or good engineering to do so.

TRADE NOTES

The consolidation of Whiting Foundry Equipment Company, of Harvey, Illinois, and American Foundry Equipment Company, of New York City, recently announced, has not been consummated and the two companies will continue as separate concerns the same as heretofore.

Joel R. Hill, consulting engineer, of Richmond, Virginia, has returned from White Sulphur Springs, Montana, after a ten weeks trip of investigating iron ore property and titles which Messrs. Coates and Comer have sold to the Montana Iron and Steel Corporation. This corporation was organized by Mr. E. A. Schubert, of Roanoke, Virginia, and P. A. Comer, of Butte, Montana.

W. R. Miller & Co. will move their headquarters to their new office building on Mt. Washington, Pittsburgh, Pa., about February 1, 1921.

Falcon Steel Company announce the opening of a New York office at room 1904, No. 18 East 41st street, New York City. T. H. Warner has been appointed district sales manager. Mr. Warner has had offices at 220 Broadway. John D. Fitzpatrick will be transferred from the home office to the new territory and will be located with Mr. Warner in the New York City office.

TRADE PUBLICATIONS

The Younstown Sheet & Tube Co. have issued an attractive calendar for 1921, containing two-color illustrations showing interesting processes in the manufacture of iron and steel. The calendar will be sent to anyone on receipt of six cents in postage to cover cost of wrapping and mailing.

The International Oxygen Company have issued Bulletin No. 61, covering the design, construction and operating characteristics of the I. O. C. System, Electrolytic Oxygen Hydrogen Generator Type 1,000.

The C. and G. Cooper Company have recently published a new book on "Gas Engines" which is one of the best ever published.

The many representative Cooper gas engine plants illustrated in it tell a convincing story of the progress in this field. For compressor service in the natural gas trade, gas engines are in special favor. In fact they have become the standard unit of power in the natural gas industry. The book also briefly describes their engines, and altogether is of considerable interest.

C-H Motor Control Apparatus for Pumps, Compressors and Similar Serv-

ice" is the title of a 40-page, (8½ x 11) booklet recently published by The Cutler-Hammer Ffg. Company, of Milwaukee, Wis. This booklet, which is known as Publication 860, takes up in a general way the control of motor-driven pumps and compressors on water and compressed air systems, in mines, on board ships, for hydraulic elevators, etc., and tells how Cutler-Hammer has attained an enviable national reputation in this field. Every C-H product used for this class of service is described, including manual and automatic starters and speed regulators, and accessories, such as pressure regulators, float switches, push buttons, etc. A condensed chart is given to aid in the selection of the proper control equipment for each particular class of service.

Metal and Thermit Corporation, of New York, have recently published a complete booklet entitled "Thermit Mill and Foundry Practice." It describes completely many interesting examples of Thermit welding.

McCrae's Blue Book, one of America's foremost buying guides, has been recently published. It is one of the most useful guides ever published, as it contains, arranged in alphabetical order, the names and addresses of 35,000 of America's leading manufacturers, showing in thousands of cases, location of branch offices; indexed under 14,000 classifications of material, and supplies the names and addresses of these 35,000 manufacturers with brief selling talks on the merits of the advertisers' products.

New Directory and Market Data Book. Crain's Market Data Book and Directory of Class, Trade and Technical Papers, now on the press, promises to be of unusual interest to advertisers generally and users of trade and technical papers in particular. It not only lists all of the business publications of the United States and Canada, giving circulations, rates, type page sizes, closing dates, etc., but supplies a market analysis of each trade, profession and industry. Thus the read is given the basic facts of each line in which he may be interested, including its buying power, buying methods, character of requirements, etc. The volume, which is bound in cloth and contains nearly 500 pages, is published by G. D. Crain, Jr., 417 South Dearborn street, Chicago.

A complete booklet has been published by Adam Hilger Ltd., London, England, on "Optical Methods in Control and Research Laboratories." It treats of the Spectrometer and Spectrograph for emission Spectra, Refractometers, and Polarimeters.

Many of the interesting publications of the year are listed under Technical Literature of Iron and Steel 1920, in this issue.

Books Received.

"Modern Welding Methods," by Victor W. Page, M.S.A.E. Price \$3.00.

The Norman W. Henley Publishing Company, 2 West 45th street, New York. It is not an engineering book but a work that gives the information a factory executive and shop man wants about all kinds of welding, soldering and brazing processes. It considers in detail oxy-acetylene welding, the Thermit process and all classes of electric arc and resistance welding. It shows all the apparatus needed and shows how to use it. It considers the production of welding gases, construction and operation of welding and cutting torches of all kinds. It details the latest approved methods of preparing work for welding. All forms of gas and electric welding machines are described and complete instructions are given for installing electric spot and butt welders. Cost data is given and all methods of doing work economically are described.

Holtz & Co., Inc., have issued a folder on their Amsler Standardizing Boxes for checking tensile and compressive loads of testing machines.

Whitcomb Blaisdell Machine Tool Company, 53 Franklin street, Worcester, Mass., recently issued a bulletin describing their Portable Shapers.

S. S. White Dental Mfg. Company, in their 32-page booklet on Flexible Shaft Driven Tools describe flexible shaft driven tools and tool holder of value to the die sinker.

Buffalo Forge Company, Buffalo, N. Y., in their Bulletin No. 311, describe Buffalo "Armor-Plate" Power Bar Cutters and the style of knives used.

Tomkins-Johnson Company, Jackson, Mich., in their recent bulletin describe and illustrate a universal vise that will not weaken under the severe strains of modern machine tools. It can be set at any angle from 0 degree to 45 degrees.

The second edition of "Research and Methods of Analysis of Iron and Steel" has just been published by the American Rolling Mill Company, a company which has always stood out as a leader in the adaptation of science to practical problems of steel making.

The second edition has been entirely rewritten, many methods have been added and the entire scope amplified by the addition of new material.

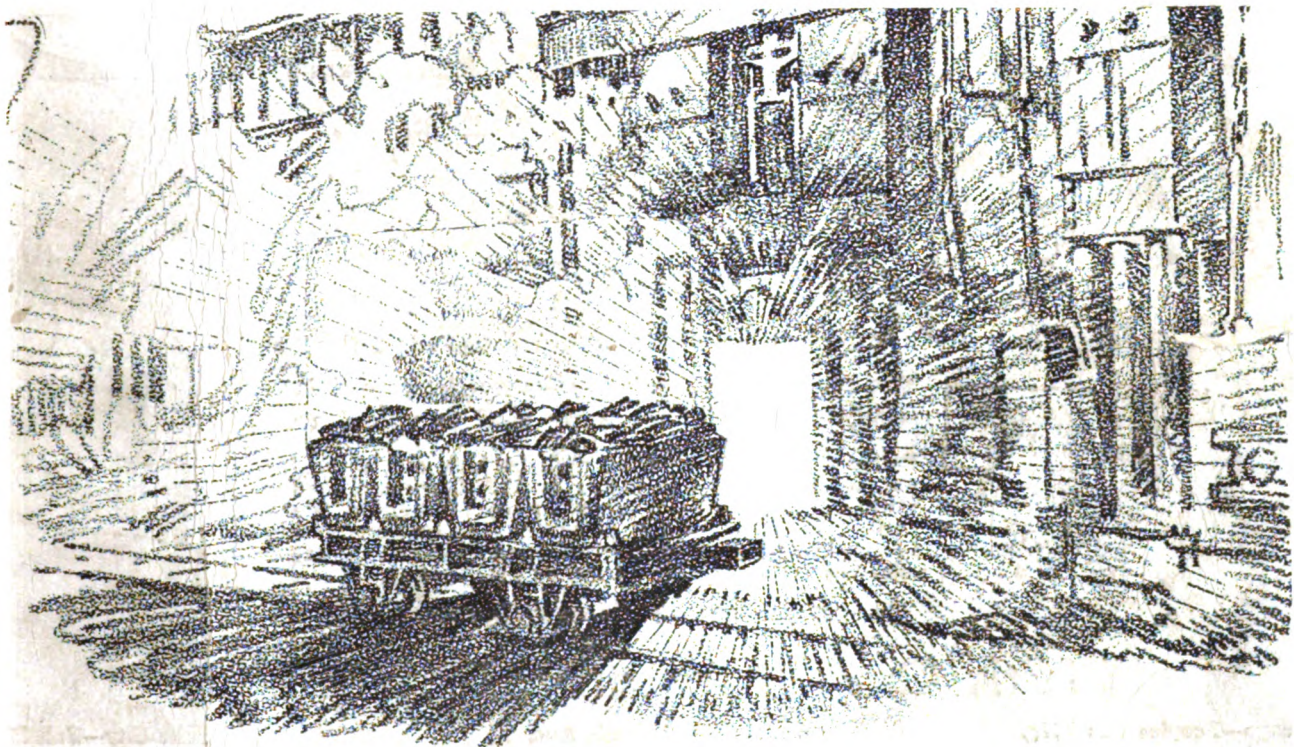
The price of the new edition is \$4.00.

Arrangements have been made by the Union Miniere du Haut-Katanga with the Garred-Cavers Corporation, for the use of their process, whereby pulverized coal is used to replace coke in blast furnaces.

The Union Miniere du Haut-Katanga have placed orders for a 42-inch Fuller Mill and a Fuller-Kenyon Pump for the coal preparation plant which will be used in connection with the above process at their copper smelter in the Belgium-Congo.

The Blast Furnace *and* Steel Plant

Pittsburgh, January, 1921.



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